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ACTA CHIRURGIAE PLASTICAE, 58, 14, 2016, p. 3–4

Dear colleagues,

On 28th June 2014 there was the assassination of the Crown Prince of Austria, Franz Ferdinand Carl Ludwig Joseph Maria, Archduke of Austria-Este in Sarajevo. The Austro-Hungarian Empire declared war to Serbia, where the steps of assassins led. Triple Alliance and Triple Entente joined the war and World War One started. This was special in many ways. It was the first war to which the United States of America also contributed; the first war where also colonies of the fighting European states joined the battles; the first war that is called the "world war". It was the first time when weapons of mass destruction were used; it was the first time for tanks, flame gun and also chemical weapons to be used. It was the first war in which the life of public was stigmatized even more than the life of the soldiers. The conflict was destructive, however, even such horrors result in positives and one of them was undoubtedly a great development of reconstructive surgery. The result of such development was that doctors from various surgical specialities, who dealt with reconstructive surgery, joined together in some way and a separate specialty – plastic and reconstructive surgery – was established. A bit later, plastic surgery was associated with aesthetic surgery, which is actually a sort of reconstructive surgery.

Plastic surgery is not a specialty that deals with treatment of some system or type of a disease. Plastic surgery performs the procedures everywhere in the whole body; it treats patients and complications from every other specialty and any type of disease. What is the unifying factor is the surgical technique and philosophy, i.e. work that is a combination of destruction and reconstruction, which is at the border between surgery and aesthetics, craft and art.

The Czech school of plastic surgery has a unique tradition, which dates back to the academician František Burian. František Burian was actively present in the birth of plastic surgery as a separated specialty; thanks to him, in the Czech Republic there was established one of the first departments of plastic surgery in the world and thanks to him the Czech plastic surgery is still known worldwide. František Burian also contributed to establishing of the journal *Acta Chirurgiae Plasticae*, which has been published since 1959 and which is special by its tradition and focus. In the subtitle of the journal it reads that it includes wider range of specialties, which are at the border of reconstructive surgery and aesthetic surgery – plastic surgery, hand surgery, maxillofacial surgery and burn surgery.

Plastic surgery in our country is a very respectable specialty, which is able to do exceptional things, which deals with exceptional complications, congenital disorders, treats defects after injuries, after resection of tumours, deals with replantations, and hand surgery.

In the recent years, plastic surgery in our country is however endangered and there is gradual weakening, or even slow destruction happening. It is a slow process and therefore inconspicuous, many of us do not realize it. Destruction comes from outside and from inside.

Internal destruction comes directly from us, from plastic surgeons. It has undoubtedly economical reasons. This is manifested by the phenomenon that many plastic surgeons after completing the training immediately leave partially or completely from clinical workplaces to private practice and deal only with aesthetic surgery and they are not interested in the development of reconstructive surgery. Even the general problems of the current life philosophy should not be omitted, which can be characterized by the words "do not bind yourself, get free" or "have fun", etc. When I ask the students (the number of male students is alarmingly declining) during my teaching classes what they want to do after completing the studies, only a very small percentage of them want to do surgical specialties. The argument is that it is "poorly paid hard work", which is unfortunately not illogical. Students and also young colleagues often lose the desire to achieve something, to be exceptional, to bring something new and it seems that the only motivation of their efforts and work is financial benefit. Undoubtedly another economical effect is great and logically poorly understandable undervaluation of complex specialized reconstructive procedures, when the site where these procedures are performed is persecuted for poor management, which certainly cannot positively motivate anyone in the development of reconstructive surgery.

Weakening from outside is more visible, we are more aware of it, but unfortunately only in the field of aesthetic surgery. All medical specialties try to gain as much as possible from aesthetic surgery and aesthetic medicine, mainly non-invasive and mini-invasive specialties are very active from this point of view. They openly claim that it should be based in legislation that these procedures should be performed only by a doctor with specialisation in this field, and it is not plastic surgery. Weakening is however also significant in reconstructive surgery. Only a few years ago there was only minimal number of doctors from other specialties than plastic surgery attending hand surgery congresses. It is now completely different. More and more doctors now start to perform reconstructive microsurgical procedures, mainly in trauma and maxillofacial surgery, which has previously been an untouchable domain of plastic surgery.

I do not mean to complain about these attempts or say that it is wrong. On the contrary, I admire these doctors and those departments. They are motivated by the effort to achieve something, to bring something to the field and to develop it. Thus, exactly what we, as plastic surgeons, are slowly losing. Part of their activities is caused by the fact that recently, it has been a real problem to find a plastic surgeon, who would be willing to perform promptly and willingly these superspecialized demanding procedures.

And this is what I consider alarming. Plastic surgery can maintain the respect of other medical specialties, insurance companies, ministry officers and patients only when it keeps strong and exceptional reconstructive surgical part. Aesthetic surgery is important, it is important to perform it at a high level and with elegance, but it will not provide us with any respect, admiration or strong position.

The success of a medical specialty is manifested also by publication and scientific activity. We can be proud that the Journal of the Plastic Surgery Society, *Acta Chirurgiae Plasticae*, has been published for more than 50 years, however its respect and viability copies the overall situation in our specialty.

I was asked to assemble the first issue of *Acta Chirurgiae Plasticae* in 2016 as a member of the editorial board. It was not a simple task since there were only three months reserved for it. We would like to present here the work of our and also foreign authors, which concerns important areas of plastic surgery. The article from the field of hand surgery comes from the colleagues from Switzerland and it deals with the differential diagnostics of symptoms in the area of the nail bed of the fingers. The article from reconstructive surgery of the breasts was written in cooperation with the Technical University in Liberec, and using numerical analysis it describes differences in reconstructive possibilities using breast implants. The article from maxillofacial surgery describes the possibility of mini-invasive treatment of condylar fractures of the mandible and it comes from the Department of Maxillofacial Surgery of the General University Hospital in Prague. The case report written by the colleagues from the Trauma Centre of the Military Hospital in Prague describes reconstruction of a forehead defect after an impressive fracture. The other two articles deal with allogeneous transplantations of composite tissues, which I consider to be the top topic of the current reconstructive surgery from the technical as well as ethical point of view. The first article comes from the colleagues from Belgium and deals with tracheal transplantation; the other article is a brief summary of current knowledge in this field. And finally, there is a presentation of general and extensively discussed topic, prevention of thromboembolic disease and pulmonary embolism in plastic and aesthetic surgery.

Dear colleagues, it has been more than one hundred years since Czech plastic surgery developed in the front position of the world plastic surgery. Now it is retreating although it has been flourishing in the world. It is only up to us whether we maintain its respect and strong position from the medical as well as economical point of view. It is disputable from the scientific point, but people say "if we put a frog to a kettle with boiling water, it tries to get out, to rescue itself". However, if we put it to a kettle with cold water and heat it up very slowly, it loses protective reflexes and it lets itself to be boiled slowly. I do not want to be sort of a pessimist, however I have a feeling that we are sitting in lukewarm water in a kettle under which is a fire. There is fire but we do not see it, or we do not want to see it. I therefore pray with the words on the statue on the Wenceslas Square: "St. Wenceslas, do not let us die nor those yet to come!"

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EVALUATION OF COMPLICATIONS AFTER ENDOSCOPY ASSISTED OPEN REDUCTION AND INTERNAL FIXATION OF UNILATERAL CONDYLAR FRACTURES OF THE MANDIBLE. RETROSPECTIVE ANALYSIS 2010–2015

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ACTA CHIRURGIAE PLASTICAE, 58, 1, pp. 5-11

SUMMARY

Background: The authors present their experience with endoscopy assisted open reduction and internal fixation of condylar fractures of the mandible. Their results are presented in a retrospective study of 33 patients with unilateral subcondylar fracture, who underwent a surgical procedure between 2010 and 2015. Reduction and fixation, stability of occlusion 12 months after the operation and also presence of complications were evaluated.
Results: Satisfactory reduction (anatomic or physiologic) was achieved in 31 patients. Stability of occlusion was worse in 1 patient (due to condylar absorption). Complications included mainly inflammatory complications (4 patients) and temporary paresis of the facial nerve (3 patients). Impaired function of temporomandibular joint was not reported in any of the patients.
Conclusion: Endoscopy assisted open reduction and internal fixation is an alternative to classical surgical procedures, however it requires special instrumentarium and experienced surgical team.

KEYWORDS

Endoscopy, mandibular fracture, condyle, complications

INTRODUCTION

The beginning of endoscopy in medicine dates back to the first half of the 19th century and it is associated with the name of Philippe Bozzini, who developed a primitive endoscope for examination of urethra, rectum, nasal airways, oral cavity and ear. Endoscope in maxillofacial surgery found its place in arthroscopy (endoscopy of temporomandibular joint), sinusoscopy (endoscopy of paranasal sinuses) and sialoendoscopy (endoscopy of salivary glands).

Endoscopy in traumatology of facial skeleton has been used for treatment of condylar fractures of the mandible and also for treatment of orbital base fractures.

Condylar fractures of the condyle belong to the most common types of fractures of the facial skeleton; they comprise 20–50% of fractures of the mandible.[1] There are common fractures of the head of the joint (intracapsular), at the site of the condyle (condylar) and base of the condyle (subcondylar).[1]

Treatment of these fractures is conservative (intermaxillar fixation for 10–14 days with subsequent rehabilitation) or surgical (using stable osteosynthesis). Both methods have currently their advocates and opponents, whereas the main argument against open surgery is a real risk to injure the facial nerve.[2] This risk is minimized by the intraoral approach, when reduction and fixation of the fracture is performed with the assistance of an endoscope. The first publication about endoscopy assisted open reduction and internal fixation (EAORIF) of the condylar fractures of the mandible comes from Germany from 1996 (Mokros and Erle) and from USA from 1998 (Lee).[3,4]

Authors of this paper present their experience with treatment of condylar fractures of the mandible with endoscopy assistance in a group of 33 patients, who underwent this type of operation at the First Faculty of Medicine of Charles University and General University Hospital in Prague (Stomatology Department, Department of Maxillofacial Surgery).

MATERIAL AND METHODS

During the period of 2010–2015 there were totally 95 patients who sustained a condylar fracture of the mandible treated with open surgery with subsequent osteosynthesis. EAORIF was used in 33 patients (34%). The remaining 52 patients were treated from retromandibular, subangular or endaural approach.

The criterion for indication of EAORIF was localisation of the fracture, while all the cases were of subcondylar type (Fig. 1); furthermore also the presence of only unilateral condylar fracture and also consent of the patient with this method. From the total number of 33 patients there were 10 men and 23 women; the average age was 36.4 years (19–68 years). 15 patients had also another fracture of the mandible (in 8 patients the angle of the mandible, in 7 cases body of the mandible).

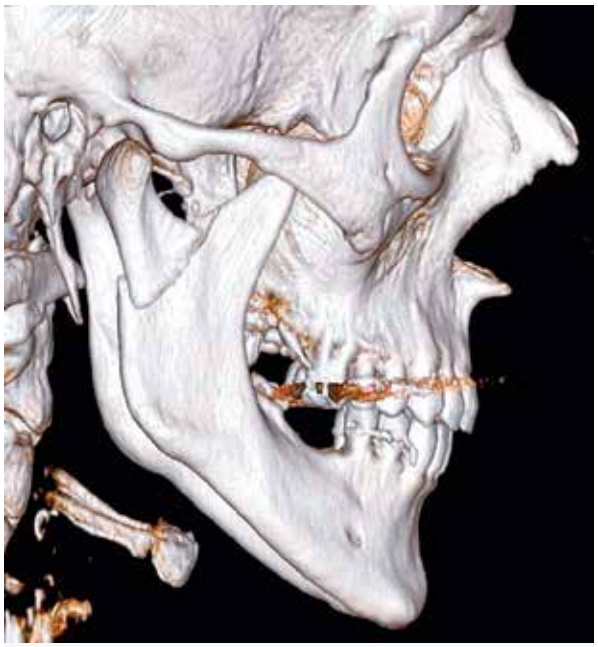

Fig. 1. Subcondylar fracture on 3D CT

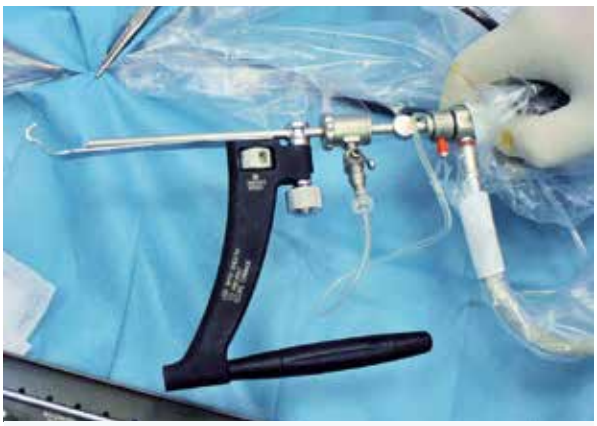

Fig. 2. Retractor with endoscope used for EAORIF

Endoscopy assisted osteosynthesis of the condylar fracture of the mandible

The authors of this paper used specialized osteosynthetic instrumentarium (Synthes Company, Switzerland), and also an endoscope with optics with a diameter of 4 mm with angulation 30° (Karl Storz Company, Germany) (Fig. 2). The surgical procedure was performed from intraoral approach; an "S" incision in the retromolar area on the side of the fracture was performed; then the insertion of masseter muscle was released; subsequently was introduced an endoscope on the lateral side of the ramus mandibulae and under direct visualisation were identified fragments of the fracture. Their reduction followed. Fixation of fragments of the fracture was performed always with rigid intermaxillary fixation, and there were totally six miniscrews used that were introduced to the alveolus of the upper and lower jaw in all cases; screws were connected together with a wire loop. Miniplate was introduced to the fracture line intraorally; drilling of the holes for miniscrews took place through transbucal trocar with subsequent introduction of the miniscrews. (Fig. 3). At the end of the operation was removed rigid intermaxillar fixation by the removal of the wire loops. Fixation screws in the alveolus were kept.

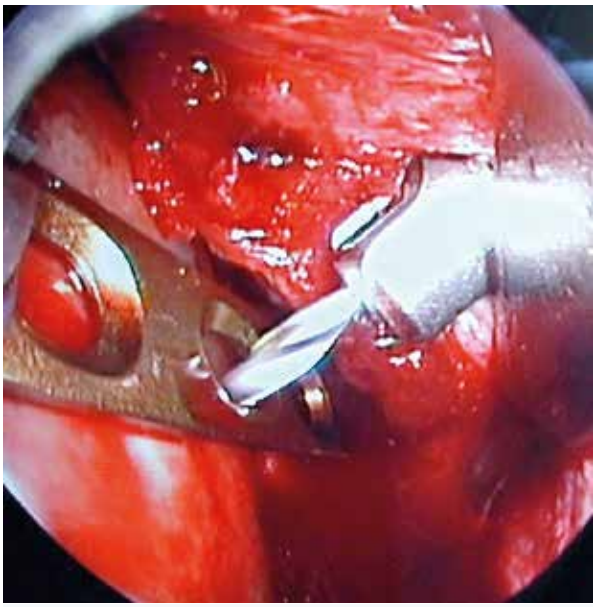

Fig. 3. View on the monitor in the area of the condylar fracture of the mandible – miniplate and introduced trocar through bucal mucosa with a drill

Postoperative care

After operation was performed adhesive tape fixation of the face to reduce postoperative swelling, which was removed 24 hours after the procedure. The authors used a simple elastic intermaxillary fixation in all cases (elastic tractions were placed on fixation screws in the alveolus), which was kept in the patient until the 7th postoperative day. Fixation screws were also removed with removal of elastic tractions. Rehabilitation of mouth opening started after removal of elastic intermaxillary fixation (i.e. 8th postoperative day, when the patient underwent rehabili-

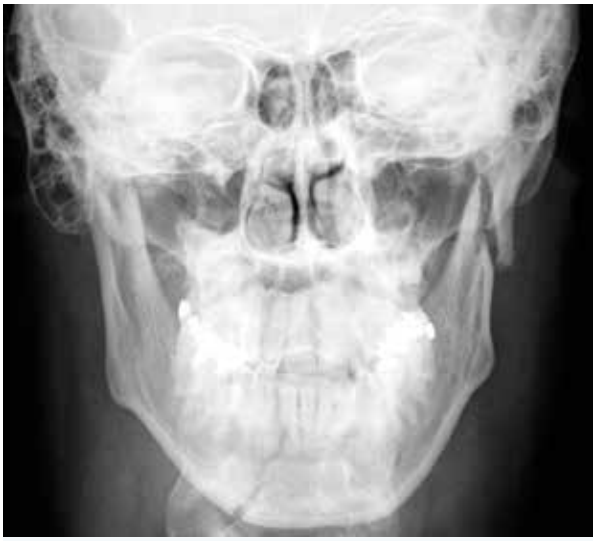

Fig. 4. Postero-anterior view of the skull – subcondylar fracture with lateral displacement

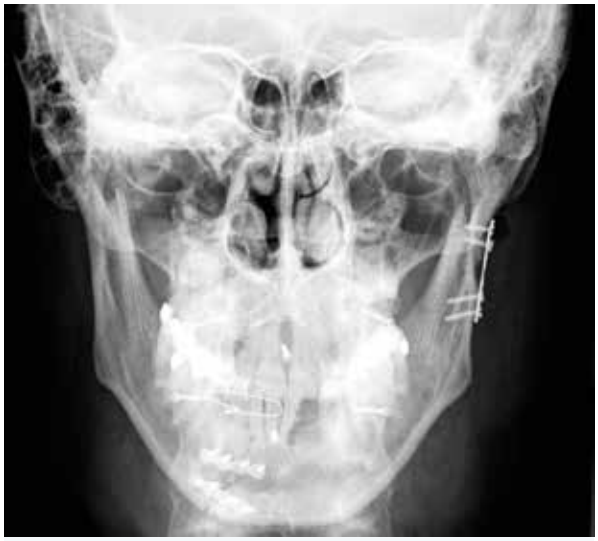

Fig. 5. Postero-anterior view of the skull – condition after fixation of fragments with a miniplate with EAORIF method (patient from Fig. 4)

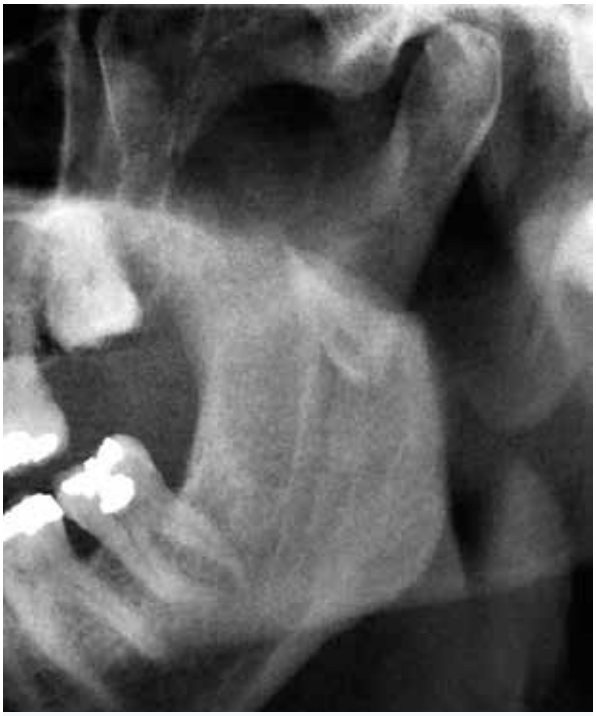

Fig. 6. Cropped image of a panaromatic image of a patient from Figures 4 and 5 – subcondylar fracture

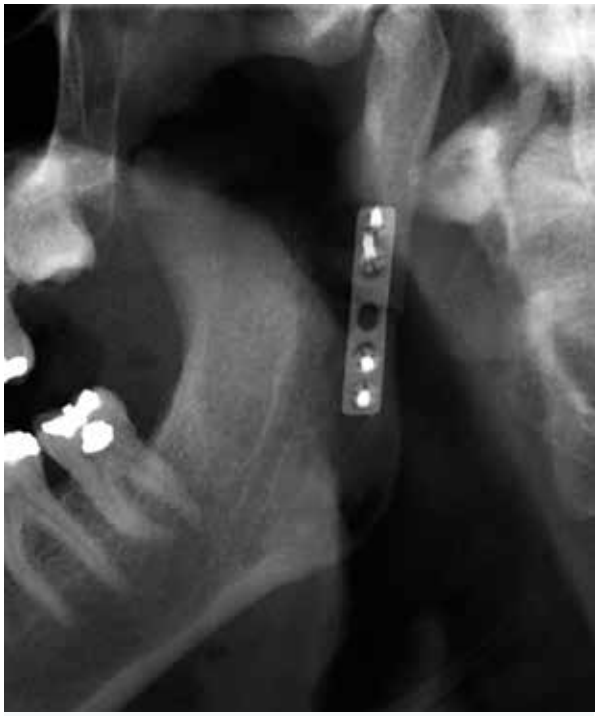

Fig. 7. Cropped image from a panoramatic image of a patient from Figures 4 and 5 – condition after reduction and fixation of a fracture with DCP plate

tation of mouth opening for the subsequent 3 weeks (opening of mouth at least 5 times a day for 5 minutes to the pain level. From the 6th week the patient underwent rehabilitation of symmetrical mouth opening (using isometric exercises).

Every patient starting from patient number 15 received a suction Redon drain to the surgical wound, which was removed 24 hours after the operation.

Evaluation of results

Evaluation of reduction and fixation was performed on the 1st postoperative day based on X ray pictures (panoramatic image and postero-anterior image of the skull). (Fig. 4–7.) Reduction of fragments was evaluated as anatomical (fragments are in ideal position), physiological (fragments are in appropriate position, however there may

be displacement of fragments up to 2 mm) and malposition (when fragments are displaced more than 2 mm, or in very inappropriate position, when height of the condyle of the mandible was not restored, or displaced fragment with joint head was not reduced to the socket).

Surgical time and presence of complications were also evaluated.

Evaluation of complications was divided to:

- intraoperative complications: bleeding, loss of osteosynthetic material (evaluated all 33 patients)
- postoperative complications: wound infection, prolonged healing, injury to the facial nerve, change of occlusion, presence of salivary fistula. Evaluation of postoperative complications was performed for the period of first 12 months after operation (evaluation of 30 patients).

Furthermore, there was function of temporomandibular joint (TMJ) evaluated in 12 months after osteosynthesis (evaluation of 30 patients), while maximal opening of the mouth was recorded (measured between incisive teeth) with symmetry of opening and also presence of pain or pathological sound phenomena.

RESULTS

Between 2010 and 2015 there were 33 patients treated with EAORIF, in all cases for subcondylar fracture, while the type of displacement was:

- shortening of the height of ramus mandibulae with displacement of the proximal fragment laterally (*dislocatio ad longitudinem cum contraction – 20 patients*)
- displacement with angulation of the proximal fragment (*dislocatio ad axim – 13 patients*); in 4 patients there was medial angulation, in 3 there was distal angulation and in 6 patients there was ventral angulation of the fragment.

Surgical time:
Average: 100 minutes (60–198 minutes)
Average surgical time in 2010–2012: 123 minutes
Average surgical time in 2013–2015: 77 minutes

Evaluation of fragment reduction:
Anatomical: 22 patients (67%)
Physiological: 9 patients (27%)
Malposition: 2 patients (6%)

One patient with malposition was reoperated, one patient refused reoperation after considering the condition to be satisfactory.

Malposition was reported in two cases in patients with medial dislocation of proximal fragment.

Usage of a plate:
1 direct plate: 19 patients (58%)
2 direct plates: 2 patients (6%)
Lambda type of plate: 5 patients (15%)
Lag screw: 4 patients (12%)
Trapezoid type of plate: 3 patients (9%)

Evaluation of stability of occlusion (12 months after operation, 30 patients): 29 patients with stable occlusion; in one patient was reported opening of occlusion on contralateral side, according to the follow up CT due to condylar absorption).

Intraoperative complications:
Bleeding: 1 patient (3%)
Loss of osteosynthetic material (miniscrew): 1 patient (3%)

Bleeding was stopped with a tamponade using hemostatic material introduced behind the edge of the mandible.

Postoperative complications:

Facial nerve palsy: 4 patients (12%); restoration in 3 patients within 2 months, and in 1 patient within 6 months.

Inflammatory complications: 3 patients (9%), in all cases this was infection of a hematoma. After that we started using a suction drain for 24 hours after the operation (from the patient No. 15). No more such complications were reported since then.

Muscle pain (pain and occasional cramps of the masseter muscle): 4 patients (12%); duration of complaints was reported within 6 months after the procedure.

Evaluation of TMJ function:

12 months after the operation (evaluation of 30 patients).
Abduction: in all patients above 35 mm, average level: 39 mm (35–49 mm).

Symmetry of opening: in 26 patients (86%) symmetrical abduction, in 4 patients (14%) abduction with deviation to the affected side.

Pain in TMJ was not reported in any patient. Sound phenomena (crackles) were present in two patients, whereas both patients reported presence of these sounds also at the time before trauma.

DISCUSSION

One of the therapeutic options to treat condylar fractures of the mandible is conservative therapy (short term intermaxillary fixation with subsequent rehabilitation). It is suitable in non-dislocated types of fractures; it is associated with several disadvantages in case of dislocated fractures: malocclusion, alteration of physiological function of the joint, increased risk of joint ankylosis, facial asymmetry due to shortening of the ramus mandibulae. In condylar fractures, there was remodelation capability reported, however, it is present mainly in paediatric patients and this capability declines with increasing age[1].

The second therapeutic option to treat condylar fractures is surgical therapy, which is based on reduction of fracture fragments to anatomical position and their fixation with titanium miniplates. This restores occlusion and full function of the TM joint. The main disadvantage of open surgery is a risk to injure facial nerve and also an aesthetic handicap - postoperative scar in visible parts of the face or neck. This risk minimizes the use of intraoral approach, when there is a however limited view and in most cases it is necessary to use an endoscope to visualize the fracture, perform reduction and fixation.[1,2,5] The results of EAORIF (satisfactory position of fragments, stable occlusion and function of TMJ) are comparable in literature with the use of other surgical approaches.[5–12] Authors of this paper achieved anatomical reduction in 67%, physiological reduction in 27% of patients. Only in 2 patients (6%), reduction and fixation was not satisfactory. These were one of the first patients from the study group, who underwent EAORIF and this fact may be related with lesser experience of the surgeons.

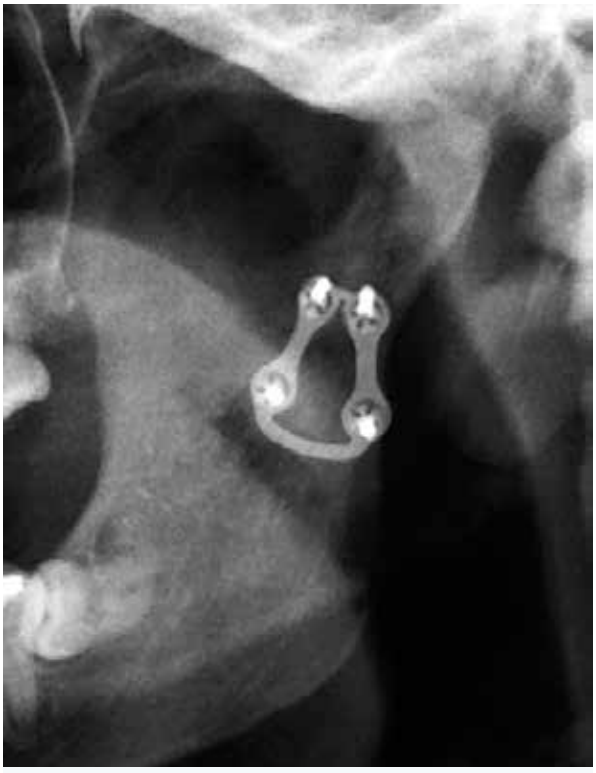

Fig. 8. Trapezoid plate fixed with EAORIF

Function of TMJ was not limited in any case; the average mouth opening was 39 mm, whereas one year after the operation was abduction of the jaw symmetrical in 86% of patients, with even movement of both condyles. Pain in TMJ was not reported. The extent of opening and symmetry of movement of the mandible is related with the necessary postoperative physiotherapy and it is greatly associated with cooperation of the patient.

The stability of occlusion after operation is related in literature with the stability of osteosynthesis.[1,5] As an adequate osteosynthesis of the condylar fractures of the mandible is recommended usage of 2 direct miniplates, while one of the plates is fixed along the axis of the condyle at the posterior edge of the mandible (for compensation of compressive forces that develop during mastication) and the second plate is fixed on the anterior edge of the condyle (for compensation of tension forces).[1,12,13] Usage of 2 direct miniplates during EAORIF is usually very difficult and relates with the experience of the surgical team. The authors of this paper used 1 direct plate in most cases (58%), 2 direct plates only in 2 patients (6%). The same effect as in 2 direct miniplates was achieved in plates of Trapezoid type (Fig. 8) and Lambda type (Fig. 9), which are adjusted in shape to compensate the forces that occur during mastication. In the presented group were the special Trapezoid and Lambda plates used in 30% of patients. In 4 patients (12%) was fixation performed with 2 lag screws (Fig. 10). However, lag screws may only be used in sheet fractures.[1]Although the authors of this paper used several types of osteosythetic material, osteosynthesis of the fragments was stable in all cases. Evaluation of occlusion (12 months after operation in 30 patients) has shown no changes in 29 patients. Only in 1 case (2%) was obvious gradual development of open bite. This was not however due to failure of osteosynthetic material, but due to the development of condylar absorption probably due to unilateral overload of the joint structures during a trauma with development of subsequent subchondral necrosis.

The disadvantage of EAORIF is the need to use specialized instrumentarium: retractors, reduction hooks and last but not least an endoscopic set. Another disadvantage of EAORIF is surgical time, which is longer than in standard open operation.[9] The average surgical time in our case was 100 minutes, while average surgical time is generally re-

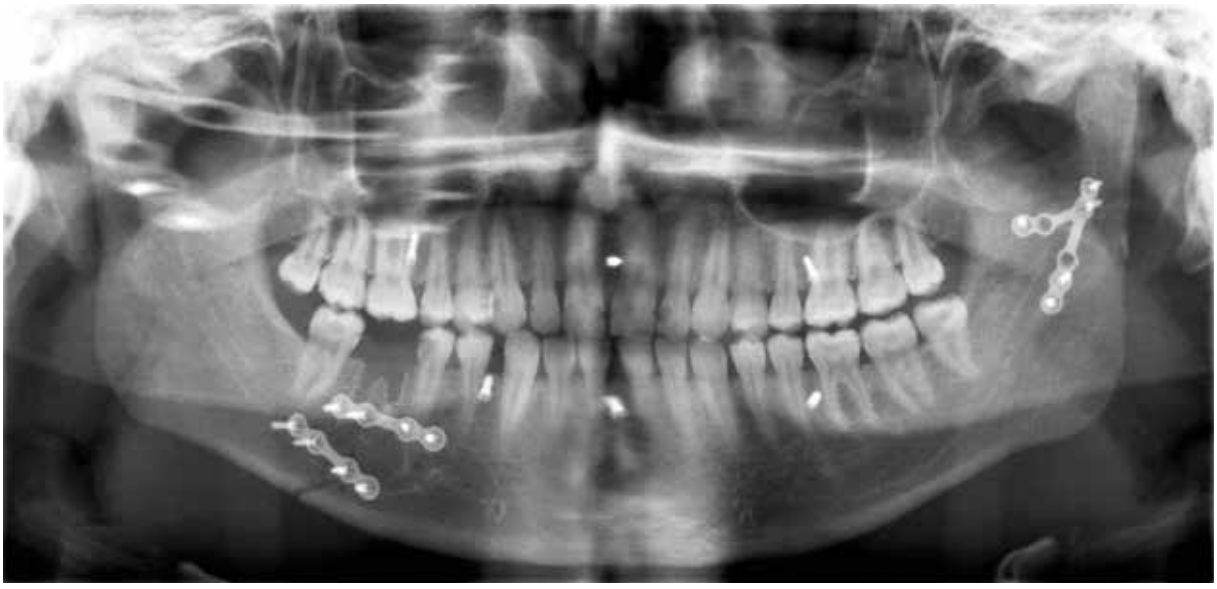

Fig. 9. Lambda plate fixed with EAORIF

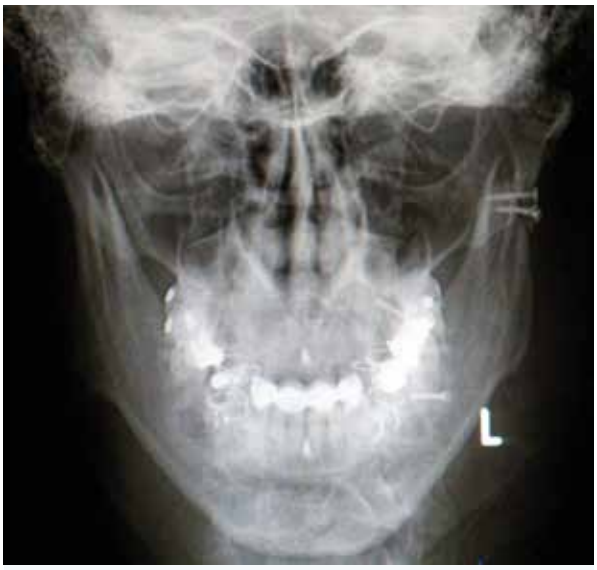

Fig. 10. Lag screws introduced with EAORIF method

ported as shorter, 50–80 minutes.[5,10,11,13,14] Authors of this paper suggest that this is due to the initially lower experience of the surgical team. Between 2010 and 2012 was the average surgical time 123 minutes, between 2013 and 2015 there was significant reduction of average surgical time – to 77 minutes.

Indication for EAORIF is mainly subcondylar fracture. Schon characterizes as an indication criterion the possibility to insert at least 2 screws to the proximal fragment (which is needed for fixation with a miniplate).[1,10,11] Type of displacement of proximal fragment is not a limitation in the indication of EAORIF[5,9–12], however the authors of this paper clearly recommend EAORIF method for the type of subcondylar fracture with shortening of the height of the ramus mandibulae with displacement of proximal fragment laterally.

Generally there are minimal complications associated with EAORIF, however the following are reported - facial nerve palsy, wound infection, salivary fistula, impaired healing, bleeding, failure of osteosynthetic material, change of occlusion, disorder of TMJ.[1,10,11,13,14,16] Kang reports that occurrence of complications rises with increasing age.[17] In our group there was bleeding reported in one case and loss of osteosynthetic material – miniscrew – in one case.

Bleeding occurs usually from intraoperative retromandibular vein or branch of maxillary artery. Bleeding may be stopped with compression using haemostatic material – in case of bleeding from retromandibular vein. In case of bleeding from the branches of maxillary artery is compression with hemostatic material usually not sufficient and there is a need to perform ligation of the bleeding vessel (from the posterior approach), rarely, however, must be performed ligature of external carotid artery.[1,16,18]

Management of loss or dislocation of osteosynthetic material is usually based on performance from the external approach and removal of material from the wound. In one patient from our group, it was possible to identify the position of a lost miniscrew only with intraoperative X ray examination, but the patient refused further surgical intervention and miniscrew remained in the surgical wound. 12 months after operation the miniscrew did not cause any problems and did not influence healing.[1]

Facial nerve palsy in association with EAORIF is reported as temporary and develops mainly due to contusion of the nerve by pulling soft tissues with retractors during operation.[1,3,5,10,11,19] In our paper was reported temporary disorder of facial nerve function in 3 patients (12%). Impaired function of other cranial nerves was not reported in the studied group by the authors.

Infectious complications do not belong to common complications. Prade reports 3 in 25 patients after surgery.[8] In our group was reported in 4 of 33 patients (12%). In all cases it was infection of a hematoma. After using suction drains for 24 hours after the operation, there were no more complications reported.

Muscle pain may occur due to trauma of a muscle and its subsequent scaring, which could cause development of muscle spasms. Authors of this paper observed this in 6 cases and always in operations where surgical time exceeded 150 minutes. Prevention of this complication is careful muscle stretching in the postoperative period.[1]

Aesthetic handicap in terms of significant scar was not reported in any case, same as other authors. The risk of a scar is related with transbucal trocar, and this is a scar with a length of several milimeters.[1,10,11,13,14,16] The need of transbucal insertion of a trocar is missing in the use of angulated instruments (screws and drills).[5,10,15]

CONCLUSION

Endoscopy assisted open reduction and internal fixation is one of the therapeutic alternatives for condylar fractures of the mandible. Its consequences are comparable with classical surgical approaches, however it significantly minimizes the risk of facial nerve injury and last but not least also an aesthetic handicap - postoperative scar. Authors of this paper also recommend usage of a Redon drain for 24 hours after the operation as a prevention of infectious complication of the procedure. On the other hand, it requires endoscopy-assisted approach of an experienced surgical team and instrumentarium to perform the surgery. As in case of every technique, also here is obvious improvement of the results due to the learning curve.

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REFERENCES

1. Eckelt U, Loukota RA. *Fractures of the mandibular condyle – approaches and osteosynthesis.* Immenstadt im Allgäu: Eberl Medien GmbH, Germany 2010, 108 pp.
2. Neff A, Neff F, Kolk A, Horch HH. Risiken und perioperative Komplikationen bei offenen gelenkchirurgischen Eingriffen. *Deutsch Zeitart Zeitschr.* 2001;56:258–62.
3. Lee C, Mueller RV, Lee K, Mathes SJ. Endoscopic subcondylar fracture repair: functional, aesthetic, and radiographic outcomes. *Plast Reconstr Surg.* 1998 Oct;102(5):1434–43; discussion 1444–5.
4. Mokros S, Erle A. Transoral miniplate osteosynthesis of mandibular condyle fractures--optimizing the surgical method. *Fortschr Kiefer Gesichtschir.* 1996;41:136–8.

5. Schön R, Gutwald R, Schramm A, Gellrich NC, Schmelzeisen R. Endoscopy-assisted open treatment of condylar fractures of the mandible: extraoral vs intraoral approach. *Int J Oral Maxillofac Surg.* 2002 Jun;31(3):237–43.
6. Cho-Lee GY, Rodríguez Campo FJ, González García R, Muñoz Guerra MF, Sastre Pérez J, Naval Gías L. Endoscopically-assisted transoral approach for the treatment of subcondylar fractures of the mandible. *Med Oral Patol Oral Cir Bucal*. 2008 Aug 1;13(8):E511-5.
7. Miloro M. Endoscopic-assisted repair of subcondylar fractures. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2003 Oct;96(4):387–91.
8. Prade V, Seguin P, Boutet C, Alix T. Outcome of endoscopically assisted surgical treatment of mandibular condyle fractures: A retrospective study of 22 patients. *Rev Stomatol Chir Maxillofac Chir Orale.* 2014 Dec;115(6):333–42.
9. Schmelzeisen R, Cienfuegos-Monroy R, Schön R, Chen CT, Cunningham L Jr, Goldhahn S. Patient benefit from endoscopically assisted fixation of condylar neck fractures - a randomized controlled trial. *J Oral Maxillofac Surg*. 2009 Jan;67(1):147–58.
10. Schön R, Schramm A, Gellrich NC, Schmelzeisen R. Follow-up of condylar fractures of the mandible in 8 patients at 18 months after transoral endoscopic-assisted open treatment. *J Oral Maxillofac Surg*. 2003 Jan;61(1):49–54.
11. Schön R, Fakler O, Metzger MC, Weyer N, Schmelzeisen R. Preliminary functional results of endoscope-assisted transoral treatment of displaced bilateral condylar mandible fractures. *Int J Oral Maxillofac Surg*. 2008; 37:111–16.
12. Meyer C, Serhir L, Boutemi P. Experimental evaluation of three osteosynthesis devices used for stabilizing condylar fractures of mandible. *J Craniomaxillofac Surg*. 2006; 34:173–81.
13. Choi BH, Kim KN, Kim MK. Evaluation of condylar neck fractures plating techniques. *Brit J Oral Maxillofac Surg*. 1997; 27:109–12.
14. González-García R, Sanromán JF, Goizueta-Adame C, Rodríguez-Campo FJ, Cho-Lee GY. Transoral endoscopic-assisted management of subcondylar fractures in 17 patients: an alternative to open reduction with rigid internal fixation and closed reduction with maxillomandibular fixation. *Int J Oral Maxillofac Surg*. 2009 Jan;38(1):19–25.
15. Kanno T, Sukegawa S, Fujioka M, Takabatake K, Furuki Y. Transoral open reduction with rigid internal fixation for subcondylar fractures of the mandible using a small angulated screwdriver system: is endoscopic assistance necessary? J *Oral Maxillofac Surg*. 2011 Nov;69(11):e372–84.
16. Arcuri F, Brucoli M, Baragiotta N, Benech R, Ferrero S, Benech A. Analysis of complications following endoscopically assisted treatment of mandibular condylar fractures. *J Craniofac Surg*. 2012 May;23(3):e196–8.
17. Kang SH, Choi EJ, Kim HW, Kim HJ, Cha IH, Nam W. Complications in endoscopic-assisted open reduction and internal fixation of mandibular condyle fractures. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2012 Feb;113(2):201–6.
18. Iwai T1, Matsui Y, Omura S, Tohnai I. Endoscopic hemostasis with an ultrasonically activated device for hemorrhage from a branch of the maxillary artery during endoscopically assisted reduction of condylar neck fracture. *J Craniofac Surg*. 2013 Mar;24(2):534–5.
19. Choi HJ1, Lee YM. Transient total facial nerve paralysis: an unusual complication of transoral endoscopic-assisted management of subcondylar fracture. *J Craniofac Surg.* 2012 May;23(3):e268–70.

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NUMERICAL EVALUATION OF SCAR AFTER BREAST RECONSTRUCTION WITH ABDOMINAL ADVANCEMENT FLAP

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ABSTRACT

Background. The treatment of breast cancer has developed a lot during the last decade, nevertheless it still remains a considerable social and economical problem all over the world. The choice of the surgical procedure depends on a patient's protocol and the surgeon's preferences. The aim of this study is to evaluate the stress on the scar after breast reconstruction.
Methods. Mathematical modeling of the sutured skin flap used for breast implant placement was divided into the following two steps. At first, material model of the selected silicone implant was identified. Afterwards, the mathematical model of the breast and implant was performed.
Results. Maximal geometrical deviation for anatomical and round implant is placed on the lower surface of the breast and upper surface of the breast, while in the area of lateral geometry and the area around the nipple the agreement reaches very high level. The maximal tension is located in two median stitches. The maximal force reaches 0.025 N. The Cauchy stress equivalent is located around the nipple and reaches the value of 380 kPa.
Conclusion. From our results it can be seen, that the anatomical and round breast implants do not result in the same stress on the scar. The maximal value difference reaches 13.4% between stress values for these two breast implants and the round implant results in higher loaded scar compared to the anatomical implant.

KEYWORDS

Scar, finite element method, breast, silicone implant, aesthetical surgery

INTRODUCTION

The treatment of breast cancer has developed a lot during the last decade; nevertheless it still remains a considerable social and economical problem all over the world. It is estimated that 89.2% of treated patients survive. However, this number still represents 22.2 deaths per 100,000 patients a year in raw data in the USA[1]. To complete the patient´s treatment, mastectomy should be followed by breast reconstruction. There are several surgical techniques used for breast reconstruction. Based on the surgeon´s suggestion, the patient can have a newly shaped breast with the use of a breast implant, his or her own tissue, or use the combination of both methods. The choice of the surgery depends on a patient´s protocol and the surgeon´s preferences. One of the used techniques is the advancement of an upper abdominal flap, skin and fat tissue in so called abdominal advancement flap (AAF). This flap pulls the elevated abdominal skin upward; this enhances the inferior portion of the breast and creates a new inframammary fold. This flap has been used for breast reconstruction in a combination with breast prosthesis for more than 40 years[2]. It can be used directly after previous expansion. It can also be called the lower thoracic advancement flap[3].

The numerical analyses, mainly finite element method, are standardized tools in biomechanics. It is commonly used for stress prediction and deformation of human tissues or implant. In breast reconstruction the finite element method (FEM) is used for surgical intervention planning. Roose et al. proposed FEM as a pre-operative simulation tool for breast reconstruction[4]. They used the CT-MR data for the breast reconstruction and linear materials models used for soft tissue. They obtained promising results, according to the authors, with the mean geometrical error below 4 mm. The material of the implant was not specified. Palomar et al. used the FEM approach to predict the real breast deformation caused by gravity forces[5]. Azar et al. proposed a new method for guiding clinical breast biopsy[6]. The results showed that it is possible to create a deformable model of the breast based on finite elements with non-linear material properties, capable of modeling and predicting breast deformations in a clinically useful amount of time. Cardaso et al. developed

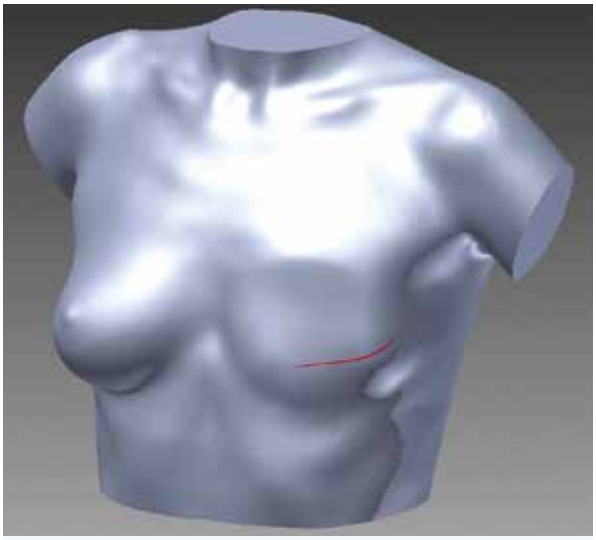

Fig. 1. Position of scar on a virtual model

a methodology and software that would allow estimating the form of the breast after surgery by knowing its form before the surgery[7].

In all works mentioned above, surgical approach was not considered to be important, only the resulting deformation of the breast was analyzed. However, the aesthetical aspect of the resulting scar is of the same importance as the breast deformation itself. Moreover, faster recovery of the patient can be achieved[8]. The aim of the following study is to evaluate the stress concentration around the sutured wound and forces on stitches after using abdominal advanced flap approach for breast reconstruction. The following null hypotheses were tested:

1. The anatomical and round implant resulted in the same loading of the wound sutures;

2. The anatomical breast implant provides better aesthetical results.

MATERIAL AND METHODS

Modeling of the sutured skin flap used for breast implant placement was divided into the following two steps. At first, the material model of the selected silicone implant was identified. Secondly, the FEM model of the breast and implant was performed. The experiments were approved by the ethical committee at the University Hospital Bulovka, Czech Republic (file No. 2012/6456/EK-Z).

Experimental part – validation

Proposed standardized implant is based on the geometry of a round implant type POLYTECH 20725-285, size M. The experiment consisted of the compression tests of the real breast implant. The implant was placed into the testing machine Instron E3000 (Instron, USA) and pushed down up to 10 mm. The loading speed was 30 mm/min. After the load the implant was released and it was left to relax for one hour, the experiment was repeated four times. For a material model evaluation the following FEM model was performed. The geometry of the breast implants was scanned by NextEngine scanner (Next Engine, USA) and the geometry was cleaned in GeomagicStudio software (3D Systems, USA). The models were imported into MSC.MARC software (MSC. Software, USA). The breast implant was meshed using solid four-node elements. The lower surface of the implant was fully constrained and the upper spherical cup was loaded by a rigid surface towards the base. The material parameters of the breast implant were updated according to the experimental data.

Numerical model

In this study a three dimensional torso of a woman (29 years old) was used for the experiment. In the place of a removed breast an incision for implant insertion was made (Fig. 1). The implant models include round implant size M, 285 ml (Polytech, USA) and the anatomical implant size MX, 290 ml (McGhan, USA). The model was discretized by four-node shell elements used for the torso and four-node solid elements for the implant in the MSC.MARC software. The model consists of 32762 elements, with an average aspect ratio quality of 0.7. The material model of breast implant was assumed to be isotropic and homogenous, defined by Young's moduli and Poisson's ratio gained from previous experiments (E=0.26 MPa, ν = 0.1). The large strain isotropic model was used to represent the human skin. This constitutive model is based on Ogden energy strain function. The Ogden model is one of various strain energy functions and is very often used to describe soft tissues[9,10]. The strain energy function is written in terms of the principal stretches as

$$W = \sum_{n=1}^{N} \frac{\mu_n}{\alpha_n}\left[J^{\frac{-\alpha_n}{3}}\left(\lambda_1^{\alpha_n} + \lambda_2^{\alpha_n} + \lambda_3^{\alpha_n}\right) - 3\right] \qquad (1)$$

where μ_n and α_n are material constants, K is the initial bulk modulus and λ_i is the principal stretch.

The material constants are summarized in Table 1, and they correspond to those mentioned in the literature[11]. For numerical purposes the real clinical situation was simplified:

- The thickness of human skin was 1 mm.
- The size of elements was chosen according to convergence of results and distance between stitches in a real surgery.
- The boundary conditions consisted of the breast implant movement towards the 10 mm torso and constraining (zero xyz movement) the lateral nodes of the torso.
- The contact between the implant and skin was supposed to be without friction.
- The pre-stress of human skin was neglected.

After having the breast shape completed a final opened wound appeared and its raw dimensions were measured (Fig. 2). Next step consisted in virtual suturing of the wound. The real stitches were substituted by trust elements put into their positions. The negative coefficient of thermal expansion (-0.1 K^{-1}) was assigned to all trust elements. This step has no physical meaning but ensures the suturing procedure. The suturing procedure was performed by thermal treatment of

μ^1 [MPa]	α_2 [-]	μ_2 [MPa]	α_2 [-]
3.15×10^{-4}	26.64	3.74	4.72×10^{-3}

Table 1. Material constants for Ogden model

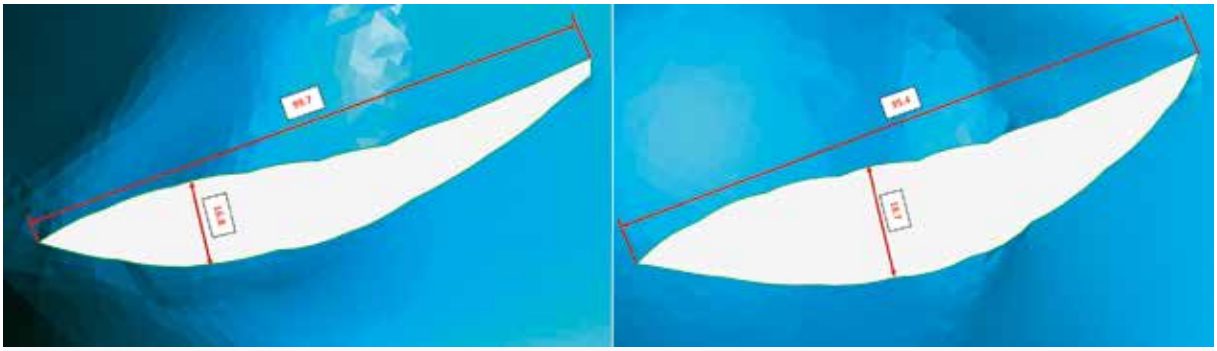

Fig. 2. Dimensions of resulted wound after placing breast implants (anatomical implant – left, round implant – right)

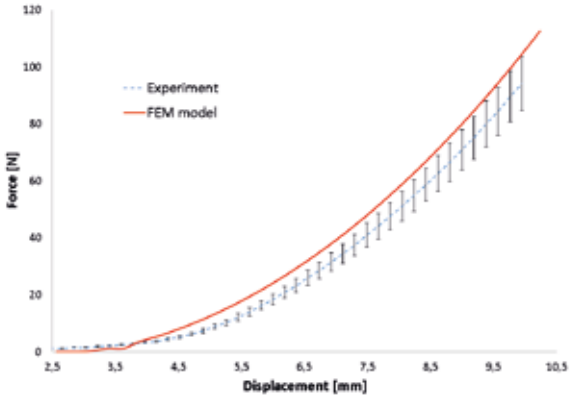

Fig. 3. Force displacement curve of uniaxial compression experiment

the trust elements, so that the opposite nodes of the wound were pushed together. After suturing the whole wound, the mesh model was frozen and exported into the stereolithographic format. The mesh of healthy and reconstructed breast was compared and analyzed by means of inspection tools of the Geomagic software. The maximal and minimal geometrical difference was found.

RESULTS

Experimental part

The force displacement curves of compressed implant are nonlinear for all the cases. The maximal force of 120 N was reached at 10 mm of compression. The fitted material model to the measured data can be seen in (Fig. 3).

Simulation part

Evaluation of geometrical accuracy was performed by measuring the Euclid distance between each node on the deformed and non-deformed mesh of the breast. The resulted color map of the deviation is shown in Fig. 4 and Fig. 5. The maximal deviation for anatomical and round implant is on the lower surface of the breast and upper surface of the breast, while in the region of lateral geometry and the area around nipple the agreement reaches very high level. The maximal and mean deviation for both models are shown in Table 2.

	anatomical shape	round shape
mean error (mm)	2.2	2.7
maximal error (mm)	7	10.2

Table 2. The mean and maximal error

The geometry of opened wounds resemble an elliptical shape. The dimensions are 97 x 16.8 mm after application of the anatomical implant and 95.4 x 18.7 mm after application of the round one. The Cauchy equivalent stress distribution around the sutured wound is presented. In case of anatomical breast implant the maximal equivalent of Cauchy stress is located around the nipple more medially and reaches the value of 329 kPa (Fig. 6). All stiches are loaded by tension. The maximal tension is located in two median stitches (Fig. 7). The maximal force reaches 0.025 N. In case of the round breast implant the equivalent Cauchy stress is also located around the nipple more medially and reaches the value of 380 kPa (Fig. 8). The maximal tension is located in two median stitches (Fig. 9). The maximal force reaches 0.0213 N.

DISCUSSION

Clinical practice shows that there are still many gaps in knowledge to be sorted with regards to patients' satisfaction with breast reconstruction. Much attention was put on the research of factors such as smoking, obesity, hypertension and age[12–15]. Nevertheless, prediction of the resulting scar after breast reconstruction has not been studied yet. There are several studies dealing with numerical analyses of skin wound suturing[16–23]. The common practice consisting in prescribing the displacement into opposite nodes of the skin wounds is used in these studies. The aim of this study was to evaluate the stress concentration around the sutured wound of the skin flap used for breast implant placement. In our models the new approach of modeling the stiches was used.

From our results it can be seen, that the anatomical and round breast implants did not result into the same scar loading. The differences are in the distribution of equivalent Cauchy stress around the resulted scar and its values. The maximal value difference reaches 13.4% between the stress values for these two breast implants, while the round implant resulted in higher loaded scar than the anatomical one. The first null hypothesis was not proved. Numerical

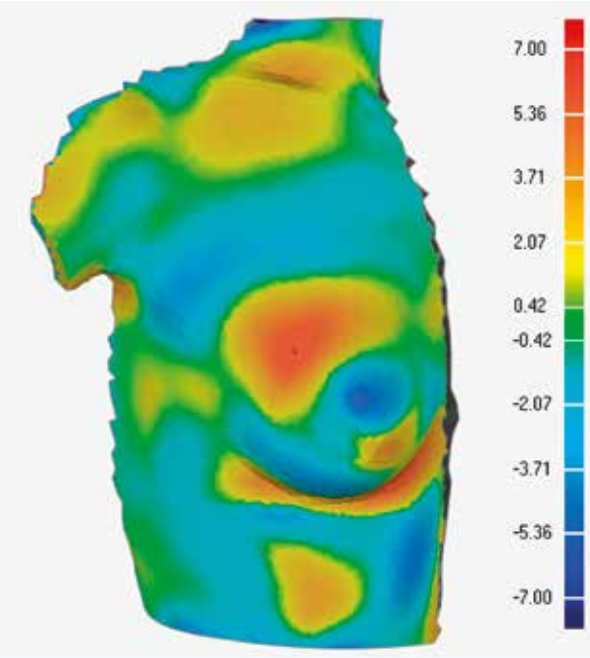

Fig. 4. Geometric deviation after breast reconstruction for anatomical implant

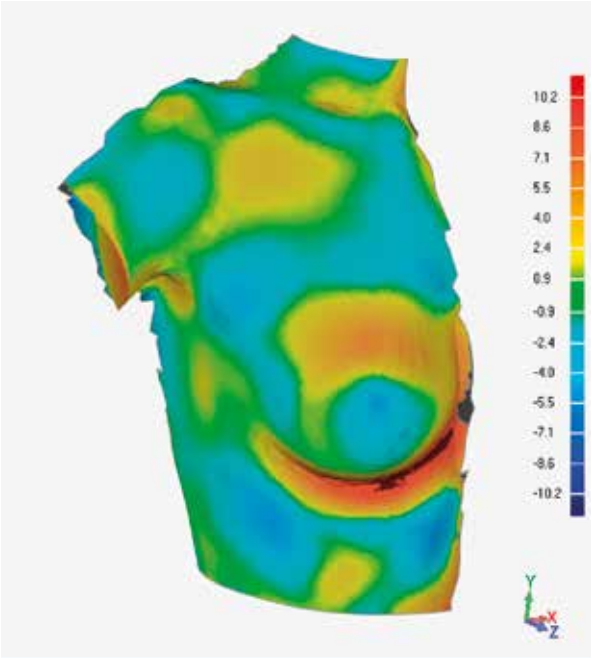

Fig. 5. Geometric deviation after breast reconstruction for round implant

analyses show that the maximum tension is concentrated in two stitches medially oriented in the sutured wound for both cases. Generally, this corresponds with surgeons´ experience. There is a lack of information regarding forces acting on stiches in different skin wounds. The force values correspond with those mentioned by Flynn on the planar models[24], nevertheless in these models the natural pre-stress of human skin was not considered. Capek et al. demonstrated that the difference between numerical models with zero pre-stress and maximal pre-stress can reach up to 44%[11]. Nelson et al. developed a model to predict risk complications in wound healing after breast reconstruction[25]. Werfully et al demonstrated that tensile forces depend on the stability of the blood clot and subsequently on the biochemical and mechanical properties of the wound bed[26]. According to our results the skin tension as an implant shape function could be another risk factor in wound healing.

The evaluation of aesthetical results from these two implants showed that the anatomical implant provides better results. It means that it fitted better to real geometry of the healthy breast. The highest geometrical inaccuracy appears in the area bellow the breast. The second null hypothesis was proved. It should be mentioned that comparison of a healthy and reconstructed breast from a pair might be misleading due to varying asymmetry of the female breast[27]. On the other hand, Yip et al. demonstrated that the breast symmetrization procedure is important and valuable for increasing satisfaction with the breast, however this is not the major outcome determinant in breast reconstruction[28].

Some limitations of this study should be pointed. The anisotropy of human skin and natural pretension were not considered in our models. In fact, the incision is usually made along Langer´s lines to minimize the wound opening in the perpendicular direction. Moreover the mastectomy

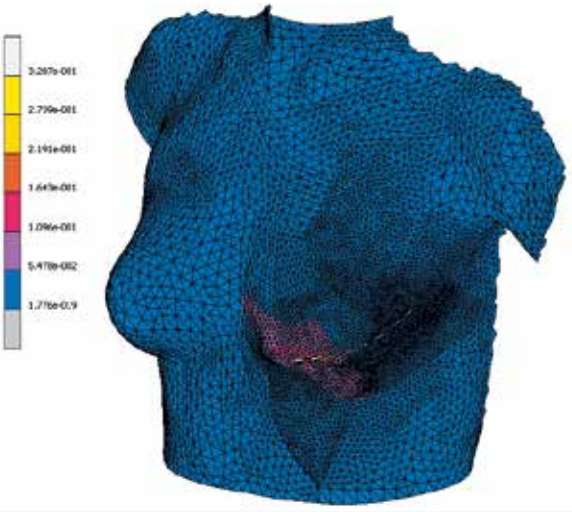

Fig. 6. Equivalent of Cauchy stress around scar after breast reconstruction by anatomical implant

was done virtually, so the simulation does not take into the consideration the real geometry of the patient after the surgery. Our next clinical study is going to evaluate the calculated force by in vivo experiments and by determining of the skin press-stress around the human breast.

CONCLUSION

The knowledge of the scar after breast reconstruction is of high importance from the aesthetical point of view. Reduction of mechanical forces around the scar prevents abnormal scar formation[29]. Delayed wound healing is costly

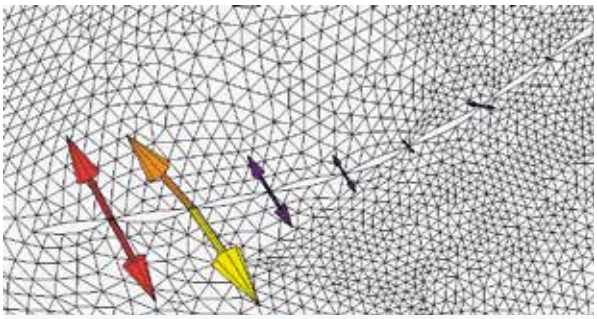

Fig. 7. Resultant forces in stiches for anatomical implant

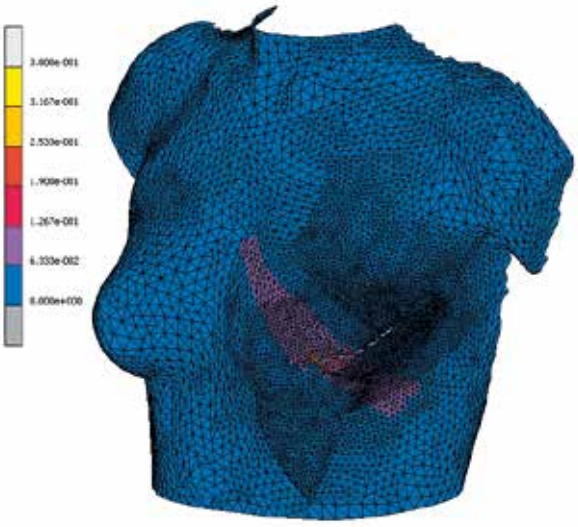

Fig. 8. Equivalent of Cauchy stress around scar after breast reconstruction by round implant

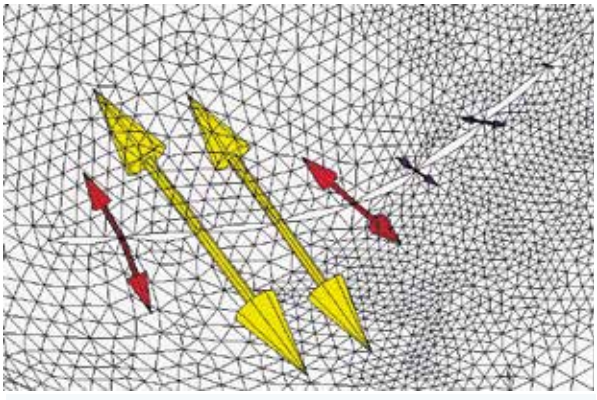

Fig. 9. Resultant forces in stiches for round implant

for the patient with breast reconstruction. The aesthetical aspect of the resulted suture is of the same importance as the breast deformation itself. In spite of this stress distribution on a resulted scar after breast reconstruction was not studied yet, according to our knowledge. It was shown, that by using numerical approach, real prediction of aesthetical results can be achieved.

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REFERENCES

1. Surveillance, Epidemiology, and End Results Program [Internet]. National Cancer Institute, USA. 2011. Available from: http://seer.cancer.gov/statfacts/html/breast.html
2. Lewis JR Jr. Use of a sliding flap from the abdomen to provide cover in breast reconstructions. *Plast Reconstr Surg*. 1979 Oct;64(4):491–7.
3. Ryan JJ. A lower thoracic advancement flap in breast reconstruction after mastectomy. *Plast Reconstr Surg*. 1982 Aug;70(2):153–60.
4. Roose L, Maerteleire W, Mollemans W, Maes F, Suetens P. *Biomedical Simulation*. Berlin: Springer Berlin Heidelberg; 2006. Chapter, Simulation of Soft-Tissue Deformations for Breast Augmentation Planning; p. 197–205.
5. del Palomar, AP., Calvo, A., Herrero, B., Lopez, J., Doblare, JM. A finite element model to accurately predict real deformations of the breast. *Med Eng Phys*. 2008;30:1089–1097.
6. Azar FS, Metaxas DN, Schnall MD. Methods for modeling and predicting mechanical deformations of the breast under external perturbations. *Med Image Anal*. 2002 Mar;6(1):1–27.
7. Cardoso A, Coelho G, Zenha H, Sá V, Smirnov G, Costa H. Computer simulation of breast reduction surgery. *Aesthetic Plast Surg*. 2013 Feb;37(1):68–76.
8. Guyomard V, Leinster S, Wilkinson M. Systematic review of studies of patients' satisfaction with breast reconstruction after mastectomy. *Breast*. 2007;16(6):547–67.
9. Holzapfel G, Ogden R. *Biomechanics of soft tissue in cardiovascular systems*. Springer, Udine, 2003.
10. Lim J, Hong J, Chen W, Weerasooriya T. Mechanical response of pig skin under dynamic tensile loading. *J Imp Eng*. 2011;38:130–135.
11. Capek L, Jacquet E, Dzan L, Simunek A. The analysis of forces needed for the suturing of elliptical skin wounds. *Med Biol Eng Comput*. 2012;50(2):193–8.
12. Butler PD, Nelson JA, Fischer JP, Chang B, Kanchwala S, Wu LC, Serletti JM. African-American women have equivalent outcomes following autologous free flap breast reconstruction despite greater preoperative risk factors. *Am J Surg*. 2015 Apr;209(4):589–96.
13. Naoura I, Mazouni C, Ghanimeh J, Leymarie N, Garbay JR, Karsenti G, Sarfati B, Leduey A, Kolb F, Delaloge S, Rimareix F. Factors influencing the decision to offer immediate breast reconstruction after mastectomy for ductal carcinoma in situ (DCIS): the Institute Gustave Roussy Breast Cancer Study Group experience. *Breast*. 2013 Oct;22(5):673–5.
14. Nelson JA, Fischer JP, Radecki MA, Pasick C, McGrath J, Serletti JM, Wu LC. Delayed autologous breast reconstruction: factors which influence patient decision making. *J Plast Reconstr Aesthet Surg*. 2013 Nov;66(11):1513–20.
15. Somogyi RB, Webb A, Baghdikian N, Stephenson J, Edward KL, Morrison W. Understanding the factors that influence breast reconstruction decision making in Australian women. *Breast*. 2015 Apr;24(2):124–30.

16. Chaudhry HR, Bukiet B, Siegel M, Findley T, Ritter AB, Guzelsu N. Optimal patterns for suturing wounds. *J Biomech*. 1998 Jul;31(7):653–62.
17. Danielson DA, Natarajan S. Tension field theory and the stress in stretched skin. *J Biomech.* 1975 Mar;8(2):135–42.
18. Kirby SD, Wang B, To CW, Lampe HB. Nonlinear, three-dimensional finite-element model of skin biomechanics. *J Otolaryngol*. 1998 Jun;27(3):153–60.
19. Larrabee WF Jr, Galt JA. A finite element model of skin deformation. III. The finite element model. *Laryngoscope*. 1986 Apr;96(4):413–9.
20. Lott-Crumpler DA, Chaudhry HR. Optimal patterns for suturing wounds of complex shapes to foster healing. *J Biomech*. 2001 Jan;34(1):51–8.
21. Retel V, Vescovo P, Jacquet E, Trivaudey F, Varchon D, Burtheret A. Nonlinear model of skin mechanical behaviour analysis with finite element method. *Skin Res Technol*. 2001 Aug;7(3):152–8.
22. Yoshida H, Tsutsumi S, Mizunuma M, Yanai A. Three-dimensional finite element analysis of skin suture. Part 1: spindle model and S-shaped modified model. *Med Eng Phys*. 2000 Sep;22(7):481–5.
23. Yoshida H, Tsutsumi S, Mizunuma M, Yanai A. A surgical simulation system of skin sutures using a three-dimensional finite element method. *Clin Biomech* (Bristol, Avon). 2001 Aug;16(7):621–6.
24. Flynn C. Finite element models of wound closure. *J Tissue Viability*. 2010 Nov;19(4):137–49.
25. Nelson JA, Chung CU, Fischer JP, Kanchwala SK, Serletti JM, Wu LC. Wound healing complications after autologous breast reconstruction: a model to predict risk. *J Plast Reconstr Aesthet Surg*. 2015 Apr;68(4):531–9.
26. Werfully S, Areibi G, Toner M, Bergquist J, Walker J, Renvert S, Claffey N. Tensile strength, histological and immunohistochemical observations of periodontal wound healing in the dog. *J Periodontal Res*. 2002 Oct;37(5):366–74.
27. Liu YJ. Aesthetics of the Female Breast: *Correlation of Pluralistic Evaluations with Volume and Surface Area*. (2009). Yale Medicine Thesis Digital Library. Paper 172. Available on: http://elischolar.library.yale.edu/ymtdl/172
28. Yip JM, Watson DI, Tiggemann M, Hsia S, Smallman AE, Dean NR. Determinants of breast reconstruction outcome: How important is volume symmetry? *J Plast Reconstr Aesthet Surg.* 2015 May;68(5):679–85.
29. Ogawa R. Mechanobiology of scarring. *Wound Repair Regen*. 2011 Sep;19 Suppl 1:s2–9.

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TRANSPLANTATION OF VASCULARIZED COMPOSITE ALLOGRAFTS. REVIEW OF CURRENT KNOWLEDGE

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SUMMARY

Transplantation in reconstructive surgery has been performed for more than 20 years, although the official beginning of these procedures is considered the first successful transplantation of the hand in 1998. The original name "Composite Tissue Transplantation" has been used less frequently; more common is the term "Vascularized Composite Allotransplant", which better describes the basis of the procedure. There have been so far approximately 180 transplantations performed, the exact number is difficult to find. The most known transplantation from this group include transplantation of the hand and face, the other, such as transplantation of the abdominal wall, joints, bones, trachea, larynx, tongue, penis, uterus, etc. are less common and less well known. The common characteristics is that they are not used for salvage or prolongation of life, but to improve its quality. The quality of life is a value, which cannot be objectively measured and the opinions regarding its importance significantly differ. Therefore there is still an unsolved ethical issue regarding these procedures, which is based on the justification to use immunosuppressive therapy with its serious risks in cases when the procedure is not needed for salvage or preservation of life.

KEYWORDS

Composite tissue transplantation, vascularized composite allograft, reconstructive surgery

INTRODUCTION

Transplantation of composite tissues as a surgical option in plastic surgery is a logical step in the reconstructive ladder. This is an allogeneic transplantation, i.e. transfer of tissues from one person to another person of the same kind. This technique, although it seems modern, had been used in the past and it has been described for the first time in a collection of bibliographies of saints called Legenda Aurea, which dates back to 1260, an the author was an Italian Dominican monk Jacob de Voragine. The event was supposed to happen 348 years after Christ. In one of the legends, Saint Kosmas and Saint Damian amputated a limb to a Christian sexton and replaced it with a limb from a dead Ethiopian person. It is difficult to assume that this event really happened, but it is obvious that the option to replace diseased or missing parts of the body with the same part from another individual has been an idea of people many centuries ago.

Gaspare Tagliacozzi, an Italian surgeon from the 16th century, describes clinical allogeneous transplantation in his book "De curtorum chirurgia per insitionem". Skin flap from the forearm of a slave was used for reconstruction of the nose of a healthy patient. The flap was not taken and Tagliacozzi concludes that allotransplantation is technically possible, but there are some practical obstacles to connect the tissues of two different individuals for sufficiently long period of time.

The name "Composite Tissue Transplantation – CTT" was developed at the beginning of experiments with transplantation of the limbs in order to differentiate it from organ transplantations and to emphasize that transplanted part of the body consists of various types of tissues, such as bones, tendons, ligaments, muscles, nerves, vessels, fat, skin, etc. The name is still used, although at the time in case of transplantations of the joints, larynx and other tissues, it looses relevance and the opponents also emphasize that even transplanted organs contain connective tissue, vessels and nerves. Currently the name CTT has often been replaced by the term Vascularized Composite Allotransplant – VCA, which more precisely defines that it is an allotransplantation of a composite block of tissues.

LEGAL ASPECTS AND REGISTERS

Transplantation of composite tissues has been performed in several countries in the whole world. It is not possible to find the exact number of these procedures, although there is an international register. This is because there is no legal obligation to register these procedures and therefore data in the register are not exact and complete; moreover data from some countries were removed due to inaccuracy and inconsistency[1,2]. There was also the International Hand and Composite Tissue Allotransplantation Society established, which organizes

regular congresses. The last congress took place in April 2015 in Philadelphia.

In the United States were the requests for these procedures registered at the United Network for Organ Sharing (UNOS) under the name VCA in July 2014. This official status and registration was necessary because from February 2014 there were 28 of these operations performed at 11 sites and another 9 patients in 6 sites waited for this procedure. In the memorandum of UNOS there were nine criteria established, which must be fulfilled for the tissue to be registered as VCA in the register:

1. tissue is vascularized and requires surgical connection of vessels, to be functional
2. contains many types of tissues
3. is harvested from a human donor as an anatomical/structural unit
4. is transplanted to a human recipient as an anatomical/structural unit
5. there is minimal manipulation (without processing)
6. it is used for homologous replacement (same function in recipient as in the donor)
7. it is not combined with another artificial device
8. it is sensitive to ischemia and therefore may be stored only for temporary, short period of time
9. it is sensitive to rejection and requires immunosuppressive therapy[3].

In every country transplantation of composite tissues must respect regulations of that particular country. Every workplace, where these procedures are performed, submits an application for approval at a responsible ethics committee and there are detailed informed consents prepared for the procedure focusing on the risks and adverse effects of immunosuppressive therapy.

When planning transplantations, it is necessary to think also of other possible legal consequences (mainly during transplantation of the face and hands) such as identification of individuals, fingerprints, etc. Mainly fingerprint is currently an identification criterion extensively used in criminology, but in some countries it is a part of passports, they are used for access to a mobile phone, to an employment facility, to protected areas, etc. Even the social aspects of the procedure should not be omitted. In Italy, e.g. after transplantation of a hand, was a disability pension removed from a patient.[4]

PSYCHOLOGICAL ASPECTS

Very important component of patient preparation is good psychological and psychiatric examination. Based on entry examination were e.g. in Italy selected only four suitable candidates for hand transplant out of 400[4] and in the United States in Louisville there were 9 candidates selected from 213 patients. Mainly in transplantations, which significantly influence the body scheme, such as hand and face transplant, are the psychological questions very important[5]. Psychological and psychiatric examination focuses mainly on issues from social history, support of the environment, general compliance with therapy, ability to make decisions, emotional and cognitive capabilities and characteristics of the recipient. Other recommended psychological examinations and preparation should focus on body image adaptation, on the ability to cope with the change of body image, on the extent of adaptation after hand amputation or facial mutilation, on accepting prostheses and epitheses, on phantom phenomenons. Finally, it is very important to properly evaluate the patient with regards to realistic expectations of the result of transplantation and in certain way also regarding the ability of the patient to accept that this therapy is still sort of clinical research and it is not possible to certainly estimate short and long-term results[6,7].

In these transplants, mainly in case of transplantation of the face and hands, it is important to know that there will be significantly higher mental pressure on the patients than on the recipients of organ transplants. There are several factors why. First, the recipient must adapt to the situation that the transplanted organ – organ from a dead person – will be visible for him/her but also for the environment, family and friends. Furthermore, the transplanted organ starts to function spontaneously and immediately, if transplantation was successful. In case of reconstructive transplantations is necessary long term and tiring rehabilitation for restoration of function and that is happening during the period of most intensive and demanding immunosuppression. These transplantations are moreover exceptional and it is necessary to consider also a great interest and pressure of media.

The most significant evidence of failed psychological preparation and examination before transplantation is the first successful transplantation of the hand in 1998, which actually started further progress. The recipient of a transplanted hand, Clint Hallam, stopped cooperating with the medical team four months after transplantation, stopped with rehabilitation and administration of immunosuppressive therapy. The limb had to be amputated two and a half years after the transplantation. Another example of failed psychological preparation is the need for reamputation of a transplanted penis in a recipient in China less than two weeks after transplantation[8].

ETHICAL ASPECTS

Transplantation in reconstructive surgery may be justified only when there are three basic conditions fulfilled. There must be a real need to perform these procedures, it must be sure that we achieve a good functional and aesthetic result with the procedure and finally the benefit of the procedure should outweigh its risks. The first condition is certainly fulfilled. There are real patients who need transplantation. Their defects mean a great physical, psychical and social burden for them and the condition cannot be solved in any other way. Achievement of good functional and aesthetic results has been shown in an experiment, but also by the experiences from clinical reconstructive surgery. Trials on animals demonstrated almost full function of the transplanted limb. The function of the limb after transplantation achieves in average 50–70% of function of the healthy limb and the aesthetic results are better than in case of prosthesis. Whether the benefit outweighs the risks is perhaps the most difficult question to answer, because it is not possible to objectively evaluate the extent of suffering and the improvement of quality of life. Similarly to all allogeneous transplantations also in reconstructive transplantations is needed life-long immunosuppressive therapy with its risks and adverse effects. And this is the most controversial point of reconstructive transplantations. Experts and lay public have been divided into two groups, to the advocates and to the opponents of the method. The basic arguments of the op-

ponents focus on adverse effects of immunosuppression due to the actual toxicity of the drugs, possibility of opportunistic infections and development of malignancies.

Transplantation in reconstructive surgery differs extensively from organ transplants. There are healthy individuals in good physical and mental condition chosen for the procedure. These individuals have no serious disease, which would significantly reduce their functional capacity and it is possible to expect better results and lower risk of adverse effects[9–11]. Questionnaire research performed in Great Britain between lay public demonstrated that only 10% of respondents were principally against the idea of reconstructive transplantation. Another research performed in the United States confirmed that people were willing to accept a higher risk in case of facial transplantation; up to 87% of healthy people would undergo facial transplantation even with 50% risk of rejection within one year[12]. These results demonstrate that lay public considers reconstructive transplantation to be useful. Research was performed also within the expert community. Among the specialists in hand surgery, there were only 13% who strongly agreed in case of a suitable indication and 7% strongly disagreed. Similar research among American plastic surgeons and specialists in burn surgery regarding transplantation of the face demonstrated that 26% of specialists consider facial transplantation to be ethically acceptable, but 6% refuses it principally regardless of the conditions[13,14].

The relationship of expert and lay public to reconstructive transplantations developed naturally. While before 2002 no publication approved facial transplantation, after 2008 almost all publications considered this procedure to be ethically justified for severe disfiguration[15].

SPECIFICATION OF DONOR SELECTION

A logical specific feature during the selection of a donor for transplantation of visible parts of the body – hand, face, abdominal wall, lower limb, etc. is that apart from immune system concordance, it is also necessary to consider aesthetic and functional concordance. It is therefore necessary to consider skin colour, race in general (mainly typical race differences on the face), character and colour of hair. Weight of the donor and recipient must also be similar; the size of the limb depends on weight and even the difference in type and extent of musculature may be surprising. Very important is also the age concordance; hand and face of an old person look completely different than in a young person. These additional selection parameters of course make the selection very difficult and limit the potential range of donors.

IMMUNOLOGICAL ASPECTS AND IMMUNOSUPPRESIVE THERAPY

Allogeneous transplantation naturally requires immunosuppressive therapy to prevent rejection. Reconstructive transplantations are not performed from vital indication but to improve quality of life of the patients. This provides benefit, but also main ethical dilemmas of these procedures. The advantage is that it is possible to select patients for these transplantations who are generally healthy and in good condition compared with patients who are in final stage of their severe cardiovascular, respiratory or metabolic disease, as in case of organ transplants. This is a clear advantage for management of complications of surgical and also other therapy, including immunosuppressive therapy. Ethics dilemma is obvious and it consists of the risk to develop malignant disease, opportunistic infections, and direct organ toxicity of drugs or metabolic changes due to the use of immunosuppressive therapy.

Immunosuppressive therapy underwent development from whole body irradiation and irradiation of transplanted organs, to the use of high doses of corticosteroids and polyclonal antilymphocytic antibodies, up to the current modern and less risky drugs[16].

Immunosuppressive regimen during CTT is not standardized for the whole body, it is not unified. It naturally depends on the customs and established algorithms of each transplantation centre, as it is in case of organ transplants. Most centres perform initial therapy with monoclonal antilymphocytic antibodies with dual combination or triple combination of immunosuppressants. Doses of immunosuppressive drugs are gradually decreased to a titrated minimum when the dose is the lowest and there is no rejection. In case of an episode of acute rejection are the doses of immunosuppressants increased in general or there is a separated bolus administration of glucocorticoids initiated and it is proceeds according to the reaction. There are also ointments with corticoids or immunosuppressive active ingredients used for skin signs of rejection.

Glucocorticoids still remain the main component of immunosuppressive therapy. Mechanism of action is variable and it has been studied extensively. In the initial phase of immunosuppression are administered higher doses (dose dependent effect) of a potent glucocorticoid, e.g. methylprednisone - decline of production of several important cytokines of inflammatory reaction occurs, which include interleukins that interfere with recognition of antigens. They also have a lymphotoxic effect. Toxic effects of glucocorticoids (myopathy, osteoporosis, diabetes) significantly decline by rapid reduction of doses, therefore it is attempted to reduce the doses to a minimal maintenance dose within three months. Glucocorticoids have also a dominant effect during the management of acute rejection[16,17].

The main advantage of monoclonal antibodies compared with polyclonal antibodies is that there is reduced occurrence of adverse and toxic effects while being homogeneous and monospecific.

These antibodies are targeted specifically against alpha chain of interleukin 2, which is selectively exprimated on activated T lymphocytes. Most frequently are used daclizumab and basiliximad. These antibodies are used for limited time at the beginning of immunosuppression and they have a minimum of adverse or toxic effects.

Azathioprine and mycophenolate mofetil are used from the group of antimetabolites. These drugs are especially suitable for chronic immunosuppressive therapy, because they influence B-lymphocytes and precursor cells in bone marrow. The most important toxic effect of both drugs is suppression of bone marrow and increased risk of malignancies. While azathioprine has higher toxicity to bone marrow, mycophenolate mofetil has more pronounced effect on gastrointestinal tract. Most units prefer mycophenolate mofetil, because it is clearly more effective in the first three years of immunosuppression[18].

Calcineurin inhibitors interfere with calcium dependent cascade of T lymphocytes, inactivate it and thereby prevent

gene transcription of interleukin 2[19]. They are very effective immunosuppressants, and it has been reported in general that immunosuppressive regimens without calcineurine inhibitors are less effective[16]. Their use requires regular monitoring of blood, because there are very important intra-individual and inter-individual variations in their absorption and excretion. Cyclosporine has been used from 1984 and it is the first drug, which enabled successful long-term use of CTA in an animal model[20–23]. Tacrolimus is a potent alternative to cyclosporine; it is 10–100x more effective in vitro. It also has a stronger stimulation effect on proliferation of hepatocytes and it has a positive effect on growth of nerves, which is important from the point of functional reconstructive transplantations. Both drugs are nephrotoxic; cyclosporine causes hypertension, hirsutism and gingival hyperplasia; tacrolimus is more neurotoxic, but only in high doses.

Sirolimus is a TOR (Target Of Rapamycin) inhibitor; it interferes with signal pathway of interleukin 2, but with another mechanism; it reduces production of immunoglobulins[24]. It has very synergistic effect with calcineurin inhibitors and its addition to immunosuppressive regimen significantly reduces nephrotoxicity of calcineurin inhibitors. Its adverse effects include hyperlipidaemia and sometimes thrombocytopenia[16].

IMMUNOLOGICAL SPECIFICATIONS OF TRANSPLANTATION OF COMPOSITE TISSUES

In comparison with organ transplantations, where the transplanted organ is consisting mainly of homogeneous parenchymatous tissue, transplants in reconstructive surgery mostly contain a complex organ, consisting of several and various types of tissues. The spectrum is wide mainly in case of hand and face transplantations. There are skin (epidermis and dermis), subcutaneous tissue, fascia, muscles, tendons, nerves, vessels, periosteum, bones, cartilage, synovium, bone marrow, and lymph nodes; in the face there is also mucosa and salivary glands. Already from the middle of the last century, it has been known that not all tissues are immunogenic the same way, i.e. they are not sensitive the same to rejection reaction of the recipient. These tissues are variably antigenic and also undergo rejection by a different mechanism. For example, muscle causes mainly cellular reaction, sometimes even stronger than skin, while skin causes generally stronger mixed, cellular and humoral immune reaction[25,26]. Generally, the most immunogenic tissue is skin, mainly epidermis and then mucosa. It is logical, because skin and also mucosa create primary barrier and protection against foreign antigens and they are very rich of professional competent immune cells.

Some kind of rejection ladder was established, which indicates the willingness of individual tissues for rejection reaction. If we consider systemic rejection (cellular and humoral), then skin is followed by subcutaneous tissue, bone, and muscle and least immunogenic are vessels, tendons, cartilage and nerves. An interesting finding was that a transplanted limb as a whole induces milder rejection reaction then individual tissues (muscles, skin, etc.) transplanted separately [25].

Sensitivity of skin and mucosa to acute rejection in the recipient is of course a great disadvantage during transplantations, because it requires higher doses of immunosuppressive drugs and it is a risk factor of failure of the whole transplantation. On the other hand, it is positive, because skin is an organ available for visual examination and signs of acute rejection (redness, swelling, papulous exanthema) can be detected very quickly without having to perform biopsy or special laboratory tests. It is then possible to initiate early and swift treatment, before other tissues are affected by rejection.

Differences in immunogenicity of individual tissues are manifested also by a phenomenon called split tolerance. This phenomenon and name was described in 1959 by Billingham and Brendt and it is a situation when one tissue from the donor is tolerated by the recipient, while the other is rejected[27]. Mathes in an experiment describes split tolerance in one organ - transplanted limb - where epidermis was rejected, while other tissues including dermis remained without signs of acute rejection only with stable mild lymphocytic infiltration[28]. Split tolerance was then confirmed also in the first patient with a transplanted hand, who stopped using immunosuppressive therapy four months after the procedure and in a sample of patients from Innsbruck and China[29]. Histological examination of the hand, which was subsequently reamputated two and half year after transplantation, demonstrated that signs of rejection were present only in skin, not in other tissues.

CLINICAL RECONSTRUCTIVE TRANSPLANTATIONS

Hand transplantation

The first, most common and probably also most known transplantation in reconstructive surgery is hand transplantation. Historically the first allogeneic transplantation of the hand was performed already in February 1964 in a 28-year-old sailor in Ecuador. In spite of therapy with corticoids, 6-mercaptopurin and irradiation, the hand had to be amputated two weeks after the procedure due to rejection[30]. The first successful operation with long-term survival of the transplanted hand was performed in 1998 in Lyon, France by a mixed team from France, Australia and Italy (Doubernard, Owen and Lanzetta). The patient stopped cooperating although the procedure was successful, the graft was taken well and the function of the limb was favourable. Since Day 120 after transplantation he stopped using immunosuppressive therapy and stopped rehabilitation and the hand was reamputated 861 days after the procedure. The first bilateral hand transplant was performed also in Lyon by the same team in 2000. So far there were approximately 30 unilateral, 25 bilateral hand transplants and 2 times even transplantation of the fingers performed[2]. Transplantation of fingers was performed in China. Reconstructive transplantation in a child was performed – according to available sources – only in one case until now and this was hand transplantation. It was a bilateral transplantation in an eight-year-old boy, who lost all four limbs due to infection at the age of two years. The patient already underwent kidney transplant and immunosuppressive therapy. The procedure was performed in July 2015, the graft took well and early results were favorable[31].

After transplantation of course follows long-term intensive rehabilitation and it has been reported that transplanted hand reaches approx. 50% of the function of a healthy hand. The patients reported improvement of quality of life approx. by 75%; all patients after operation are able to care for themselves, most of them are able to perform their original oc-

cupation, hobbies and interests. To facilitate rehabilitation there were special aids and devices developed such as sensory glove of professor Lundborg, which takes the advantage of the capacity of human brain for multimodal plasticity[32]. The problem of chronic rejection and loss of function was not yet clarified, however, in the first patient, who stopped using immunosuppressive therapy and the hand was reamputatted, was found that from all the tissues only skin underwent rejection. This finding is a great promise that even after a long time the limb can remain functional. According to the available sources it has been necessary to perform six reamputations of the limb worldwide and seven in China due to various complications.

Transplantation of the face

The second most popular transplantation of composite tissue is undoubtedly facial transplantation. The procedure is more demanding than in case of the hand and mainly the lack of success of the procedure has catastrophic consequences for the recipient. The first face transplantation was performed also in France in 2005. So far, there were approx. 35 facial transplants performed, 19x parts of the face, 16x the whole face[33]. Indications for the procedure are modified in various sites, however in general these patients are 18–60 years old, the defect of the face must be greater than 25% or it must affect dominant aesthetic and functional units such as the nose, lips, eyelids. Transplantation of the face is not useful to restore natural appearance of the face; it is used to restore function such as breathing, intake of food, taste, smell, speech and facial mimics and sensitivity. Great number of patients requiring facial transplantation suffers from loss of smell and has a tracheostoma due to obstruction of upper airways or gastrostoma due to inability to swallow food.

From the technical point of view is facial transplantation actually a transfer of (osteo)-myocutaneous free flap with the need to suture vessels and sensitive and motoric nerves. Before the procedure, it is necessary to perform detailed examination of the skeleton to visualize the actual defect and also function of the joints, tongue etc. It is also very important to examine thoroughly the recipient's vessels on the neck, because many vessels were injured or destructed by the actual trauma or resection of a tumour or were used already in the previous reconstructive procedures. The studies have shown that for revascularization of the whole face, it is enough to perform a suture of the facial vessels even in case that larger bone segments were harvested provided the harvest of the face is correctly performed with preservation of collateral vascular network. More advantageous is however performance of anastomosis in several vessels. Reconstruction of all available nerves must be performed the same way in order to achieve optimal motoric and sensory functions[33–37]. Reinervation of transplanted face occurs in approximately 18 months and from the day 10 there is a possibility to speak and eat. According to the current results, breathing recovers in 93% of patients, speech in 71% and mimics also in 71% of patients[38].

Complications in facial transplantation may be surgical, most frequently thrombosis of microsurgical anastomoses; most complications or adverse events are due to immunological reasons and use of immunosuppressants. Acute rejection occurred in 80% of patients; events were treated well. The worst, catastrophic scenario, i.e. superacute rejection with a loss of the transplant, did not occur yet. Chronic rejection was reported so far only once and manifested by restriction of function – opening of mouth and atrophy of mucosa[39].

There were also serious complications reported in facial transplantation. In a patient with a combined facial transplantation and both hands was required reamputation of the hands. There were five deaths after facial transplantation reported. The cause was lack of cooperation of the patient, suicide, recurrence of carcinoma, sepsis and lymphoma with breathing difficulties[40,41].

One of the greatest specific problems of facial transplantation is currently very short time of tolerable ischemia that is only 4 hours, which significantly restricts the geographic radius of possible donors. To prolong ischemia time it is possible to consider extracorporeal perfusion that is sometimes used in transplantation of solid organs. There is also very limited number of donors and the waiting time for facial transplantation in the United States is now approximately 180 months.

Transplantation of scalp

Transplantation of scalp was performed already in 1981 in the USA between identical adult twins-sisters. Immunosuppressive therapy was not used. The procedure was successful, complete take occurred, allo-transplantate healed without signs of rejection and from the fifth day after the procedure started growth of hair[42].

Chinese authors performed transplantation of a half of the scalp, both ears and skin of the nape in 2003 in a 72-year-old patient with extensive malignant melanoma. Male scalp was used for transplantation, not a female scalp. The defect developed after a resection of a tumour and reconstruction with transplantation was performed together with radical resection of the tumour. According to the classification of the tumour was the survival of the patient approx. 25% in 5 years. The procedure was successful; 120 days after the operation was the patient compensated, allotransplant was taken without complications. There is no more information about the fate of the patient[43]. There was rather critical discussion against the use of allotransplantation, against this technique and usage of a male donor etc. in this particular patient[44]. In 2015, the team of doctors in Houston, Texas performed combined transplantation of kidneys, pancreas and calva with a scalp. This was a patient who had transplanted kidneys and pancreas and these organs were failing. In the area of the hair bearing part of the head was performed repeated resection of a leiomyosarcoma, which resulted in an extensive defect of scalp and calva. During a fifteen-hour operation was performed complex transplantation of failing organs and part of the skull with a scalp from the same donor[45]. The procedure was successful and all transplanted tissues healed.

Transplantation of the larynx

Loss of the larynx with a tracheostoma is associated with deteriorated taste or even loss of taste and smell; there is higher incidence of upper airways infection, but mainly there is loss of voice. The affected individual is stigmatized in personal and social life, which is also documented by the research performed in patients after laryngectomy in the USA, where 75% of patients after explanation of the procedure, of the risks etc. would undergo transplantation of the larynx[46].

The most immunogenic tissue in the larynx is mucosa; cartilages are minimally immunogenic. Tolerated time of

cold ischemia of the larynx was experimentally demonstrated to be 20 hours, which is very favourable for the management of these transplantations. For adequate perfusion of the larynx should be sufficient anastomosis of unilateral superior thyroid artery and its first branch, the superior laryngeal artery; more convenient is of course performance of bilateral anastomoses[47]. Greater problem is however innervation of the larynx, which is necessary for good function and therefore for the success of the procedure - restored speech, regulation of breathing, swallowing, coughing reflex, etc. For complete re-inervation of the larynx, it is necessary to perform suture of the superior laryngeal nerve and recurrent nerve bilaterally[48–51].

The first clinical transplantation of the larynx was performed in 1969 in a patient after resection of the larynx for carcinoma. The procedure was successful, the graft was taken well and the function was restored, however 7 months after the procedure there was recurrence of a tumour and the patient died[52]. Another transplantation was performed in 1998 in the United States of America in Cleveland Clinic Foundation in case of a post-traumatic loss of the larynx with healing and restoration of function [53,54] and in Meddeline in Columbia in South America, where there were 13 of these procedures performed and the success rate was 90%[55]. Farwell from California describes another case report of larynx transplantation with a part of trachea in 2013 and it was successful[56].

Transplantation of the larynx is a very attractive procedure (it is estimated that in the world there are approx. 140 thousand patients after laryngectomy each year), but currently it is used very little since most of the patients loose larynx due to a malignant disease and immunosuppressive therapy in these patients is very discutable[57].

Transplantation of trachea

Trachea is an anatomical connection between larynx and bronchi; its function is therefore more complex – ventilation, voice, and it ensures balance of respiratory secretion. For the patency of trachea, it is necessary that it is solid in transverse direction, but elastic in longitudinal direction. This is enabled by special anatomic construction with cartilage rings connected by ligaments. The defect of trachea shorter than five centimetres may be treated with mobilisation and suture; longer defects are difficult to treat. The greatest problem of tracheal transplantation is its vascularization, which is not provided by larger vessels, but by several small segmental vessels, which are difficult to anastomose. Trachea is therefore usually transplanted individually as a non-vascularized graft, which is transplanted to a heterotopic well-perfused bed and it is transferred together to the neck or the transfer is performed only after complete take of the graft and vascularisation is restored in a second stage.

The first transplantation was performed in 1979 in two stages. For the heterotopic bed was used sternocleidomastoid muscle[58]. In 1993, Levashov described single stage transfer of non-vascularized trachea wrapped into omentum; stenosis with the need to insert a permanent stent however occurred[59]. In 31 paediatric patients was performed orthotopic transplantation of cryopreserved trachea with a success rate of 85%[60,61]. In Austria was transplanted trachea to one patient into the distal omentum, however it was not used finally, because the trachea of the patient could be reconstructed with a suture after extensive mobilisation[62]. Systematically was tracheal transplantation investigated in Belgium, where two-stage heterotopic transplantation with transfer via the forearm was performed in 2005 in five patients. After healing was trachea transplanted to the neck on radial vessels[63].

The only transfer of vascularized trachea together with the thyroid gland with vascularization using the inferior thyroid artery was performed in Colombia by Tintinago in 2003; repeatedly was also performed transplantation of larynx together with a part of trachea using the same technique[64].

Transplantation of the tongue

The tongue has a function in personal and social life; patients without tongue have difficulty speaking and speech is incomprehensible; they have problems with swallowing, they don't have taste and the tactile function is also missing. The tongue has an important function also for oral hygiene and chewing of food. Loss of tongue is usually caused by an oncological disease, only sometimes is the cause traumatic or other.

Transplantation of the tongue was performed in 2003 in Austria in a patient after resection of a tongue due to a carcinoma. Reconstructive procedure was performed together with the resection procedure after chemoradiotherapy due to advanced tongue carcinoma. Taste and swallowing restored; however, the patient died due to generalization of the original tumour. There is again a consideration about the suitability of transplantation with immunosuppression in oncological patients, however the authors, who performed the procedure state that according to studies there is no higher occurrence of carcinomas of the head an neck in patients with immunosuppression[65]. Another transplantation of the tongue was performed in 2013 as a composite transplantation together with the whole face and upper and lower jaw. This was so far the most complex transplantation in the facial area. The face of the patient was devastated after high-energy ballistic injury to the central part of the face[66,67].

Neck transplantation

Transplantation of the neck was performed in a patient in 2015 in Poland. The recipient was a patient, who previously underwent kidney transplantation many years ago. In 2009 was removed an extensive tumour of the larynx. Since the patient had no recurrence for the last 5 years, and he had immunosuppressive therapy after kidney transplant, there was complex transplantation of cervical organs – larynx, trachea, upper part of the oesophagus, thyroid gland and parathyroid glands, hyoid bones, muscles of the neck and skin island performed[68,69].

Transplantation of the abdominal wall

Abdominal wall serves apart from others for the locomotor and postural function and as an important cover of the intra-abdominal organs. Its devastation may occur by injury, tumour, but also due to recurrent surgeries with multiple scars, stomas, etc. Its covering function is dominant, mainly in case transplantation of intra-abdominal organs, such as stomach, bowel, liver, pancreas, kidneys and others are needed. Transplantation of the abdominal wall was so far performed always as a combined procedure with multivisceral transplantation. This naturally removes the ethical problem, since its performance is vitally important and immunosuppressive therapy is not used due to transplantation of the abdominal wall only, but also due to the intra-abdominal organs.

Transplantation of the abdominal wall was performed in the USA in nine patients, first in 2001[70]. Abdominal wall was harvested on iliac vessels. Iliac vessels and also intra-abdominal vessels – aorta and inferior caval vein – in the recipient were used for anastomosis. They were performed with a macroscopic technique. Most transplantations of the abdominal wall were performed from an identical donor, from whom were harvested the organs; it was twice performed as delayed procedure from another donor. In 2007, Cipriani from Bologna reported experiences of three patients where microsurgical technique with an anastomosis of the inferior deep epigastric vessels was used[71]. Authors from Great Britain performed transplantation of the abdominal wall in six patients, where the long time of ischemia of the abdominal wall was bypassed by temporary heterotopic revascularisation on the forearm vessels. After termination of visceral transplantation was abdominal wall disconnected from the forearm and orthotopic revascularisation was performed[72].

There is also a report about transplantation of a split abdominal wall, i.e. transplantation of deep abdominal fascia only. This method requires separated suture of vessels, since visceral fascia is sufficiently perfused by the vessels in ligamentum falciforme connecting with the liver. This technique was used in three paediatric patients[73,74].

Survival of patients after transplantation of the abdominal wall is relatively low. Selvagi summarizes the results of a team from USA and Italy[75]. Only five of 14 patients survived eight years after the procedure. It was important that not even one of the patients died due to direct complications of the abdominal wall transplantation; the cause of death were complications of visceral transplantation, sepsis or lymphoproliferative disease.

Transplantation of skeleton

Extensive devastation of weight bearing bones and joints in association with destruction of ligamentous and tendineous apparatus is a great reconstruction problem and it is often impossible to use standard techniques such as microsurgical transfer, segmental transport, distraction or prosthetic joints. Another option is amputation and prosthesis or joint fusion of the knee joint with shortening of the limb and subsequent distraction. Even here there is a possibility of allogeneous transplantation. For more than 50 years have been used allogeneous bone grafts for smaller bone defects, usually treated with cryopreservation. It is estimated that in the USA there were approximately on million of these grafts used in 2013.

Already in 1902 was performed allogeneous transplantation of a non-vascularized half of a joint in three patients[76]. Lexer performed 23 transplantations of non-vascularized joints including the knee between 1907 and 1925. In spite of significant radiological degenerative changes was the function of the joints good and painless[77]. In 1970, Volkov described reconstruction of a part or whole joint in 150 patients. Joints were not vascularized[78]. In patients with a transfer of small joints or small parts of joints were the results favourable; in big joints, however, were the results very unsatisfactory, basically none of the patients experienced good take and function.

The first vascularized transfer of femoral diaphysis was performed in 1990 in France with a good result. Doi reported family allotransplantation in 1994 between the mother and son with complicated healing and need of reoperations, but with a good result at the end[79].

A German team investigated this topic more systematically and performed three transplantations of a long segment of femoral diaphysis and six transplantations of the knee joint between 1995 and 2003[80]. The results were not favourable; healing was complicated with the need of reoperation and with the use of autogenous cancellous bone grafts. In case of the knee joints, one of six patients healed well with favourable function. Other joints had to be removed due to rejection, infection or lack of cooperation of the patients and below knee amputation or fusion of the knee joint was needed[81].

Transplantation of the lower limb

Transplantation of the lower limb has been refused for a long time due to two reasons. The first is that lower limb is predominantly a locomotor organ and it is very well replaceable by a prosthesis or a wheel chair. The second reason suggests that it is difficult to expect good functional results with regards to the length of the nerves, which are needed for regeneration. For correct function of the lower limbs - gait, standing, balance, stability, etc., it is necessary to achieve good reinervation of the limb in terms of motoric and also sensitive innervation, mainly in the area of the sole.

In 2012 was performed the first transplantation of both lower limbs at the thigh level. The patient was a 22-year-old young man, who lost lower limbs in a car accident. The patient was not able to walk with prostheses, refused osteointegrated prostheses and moved only on a disability wheelchair. Transplantation was successful and one year after the operation was the patient able to perform extension in the knee and plantar flexion of the foot; Tinnel sign was present at the level of the ankles[82]. Further improvement of the limb function is expected.

Penis transplantation

Penis is one of the dominants of male gender and its loss is associated with several functional, mental and social problems. The patient cannot urinate in standing position, he is unable to have sexual intercourse and fertilize the partner. The loss of penis is possible by a trauma, resection for a tumour and a large group is a result of complications of unprofessional circumcision, mainly in African countries, where the presence of penis is required for full social life of males.

Transplantation of penis was performed for the first time at the Military general hospital Guanzhou in China in 2006 in a 21-year-old male with traumatic loss of the penis. From the tenth day after the operation was the patient able to urinate; due to psychological complaints of the patient and mainly of the wife had the penis be reamputated two weeks after the operation[83,84]. Second successful transplantation was performed in South Africa in 2014. The patient lost penis after complications of circumcision at the age of 18, when he already had active sexual life. According to the reports from press was the patient able to urinate, had erection, orgasm and ejaculation five months after the operation[85,86].

Transplantation of uterus

Transplantation of uterus is for now the only one from the reconstructive transplantations, which may be really planed only for a temporary period of time and after suc-

cessful pregnancy and labour may be removed and immunosuppressive therapy stopped. This procedure is intended for young healthy women, who lost the uterus for some reason or their uterus is not functional, they are still in childbearing age and they wish to have own children. Transplantation of uterus is currently the only possible therapy of uterine infertility. Experience in young women using immunosuppressive therapy after organ transplantation demonstrate that they can successfully complete pregnancy of a healthy child[87] and in an experiment in sheep and rats was achieved complete pregnancy after uterine transplantation[88,89]. Therefore the concept of uterine transplantation to achieve pregnancy and carrying of children to term is real.

Uterus transplantation in humans was performed for the first time in Saudi Arabia in 2000. Uterus was taken well and normal menstruation bleeding occurred for 3 times. However, thrombosis of vessels and necrosis of uterus occurred after three months and uterus was removed. Another transplantation of uterus was performed in Turkey in a woman with Rokitansky-Kuster-Hauser syndrome; the uterus was taken well and regular menstruation cycle occurred. After a second embryotransfer the patient got pregnant, but in the sixth gestation week the foetus died[90]. The team of doctors from Sahlgrenska University in Gothenberg in Sweden performed a series of nine uterus transplantations between 2012–2013 in women with absolute uterine factor of infertility. In 2015 was published an article about successful full term foetus after artificial fertilization in one of these women. The patient was 35 years old and the donor of uterus was a living woman aged 61 years. In vitro fertilisation in the patient and her partner was performed before transplantation of uterus and harvested embryos were cryopreserved. One year after transplantation was one embryo transferred to the uterus and pregnancy occurred. The patient was admitted in the 32nd week due to preeclampsia and due to pathological cardiotocography record of the foetus was performed delivery with Caesarean section. Vital healthy foetus of male gender with birth weight of 1770 grams and length of 40 cm was born and only phototherapy was required. The mother was discharged to home care two weeks after labour; the child was thriving well and the weight was 2040 grams[91].

Transplantation of skeletal muscle

Transplantation of muscle may be considered in case of a devastation injury to reconstruct function, but also only to cover defects in special cases. Separated muscle has never been used for reconstruction of muscle function. In 1998, in the USA, was however performed transplantation of skeletal muscle for reconstruction of a scalp defect in a patient after resection of extensive spinalioma. This procedure was indicated as a more gentle, because the patient was already on immunosuppressive therapy after kidney transplant. Complete healing took place without rejection [92].

Transplantation of tendons

Extensive loss of tendons, mainly in the area of the forearm and hand may be equivalent from the functional point to a complete loss of the limb. Autologous tissues may be used for reconstruction. However, in case of a greater loss, it may be difficult or even impossible. Tendons have very low immunogenic potential and therefore their use as allogeneous transplant is beneficial and is associated with minimal to only temporary immunosuppressive therapy.

Already in 1959 was performed transplantation of non-vascularized flexor tendon complex containing both flexors, tendon sheath and peritenonium. Transfer of 11 tendon complexes was performed in ten patients. It was great in seven of them, the surgery failed in four of them[93]. In general the same operation with similar results was described in two patients [94]. In 1990 in France were performed 2 transplantations of fresh vascularized tendons – tendon system supplied by ulnar artery. After temporary immunosuppressive therapy the tendons healed without signs of rejection and restoration of function occurred[95].

Tendon non-vascularized cryopreserved allotransplants are commonly used in orthopaedic surgery for reconstruction of anterior and posterior cruciate knee ligament, ligamentum patelllae, extensor system of the knee and patellar instability, etc. In this case is used Achilles tendon, ligamentum patellae, fascia lata, rotator cuff, tendon of tibalis posteroir and anterior and others[96].

Transplantation of nerves

Allotransplantation of nerves was first attempted already in 1885, however without description of the functional result[97]. In the 20th century were performed several clinical transplantations of non-vascularized nerve grafts with very contradictory and disputable results. In 1990 in the USA was performed transplantation of frozen nerve allografts in patients with massive loss of peripheral nerves with exact description of the technique, immunosuppressive therapy and results. In seven procedures, there was one rejection; in 4 out of 6 taken transplants there was partial restoration of function[98,99].

Transplantation of vessels

Venous non-vascularized allografts as an alternative for bypass in patients with lack of own vascular grafts were used by Carpenter in 1997. Patency of grafts was however poor[100].

Anorectal transplantation

In an experiment on animals was performed transplantation of anorectal complex[101–103]. Japanese authors performed cadaveric transplantation of anorectal complex in one human with a suture of pudendal vessels and nerves and inferior mesenteric vessels. Surgery took 7 hours and the diameter of vessels and nerves was 1–2.5 mm. Authors concluded that the procedure is technically and anatomically possible in humans and it is intended for perspective patients with loss of anorectal complex as an alternative of life long colostoma[104].

Complex rare transplantations

As a rare transplantation may be mentioned transplantation of the left upper limb between homozygous twins in 2000 in Kuala Lumpur in Malaysia. The procedure was performed in the first month of life of the twins, when one foetus had anencephalus with severely damaged brain and unable to survive long term and the second foetus had a deformed left arm with missing hand. There was no immunosuppression administered and the graft healed well with a great functional result[105,106].

Similar procedure was performed in Canada in 2004 in two Siamese twins (non-sanguineous ischiopagus) who were not able to survive both after separation. One lower limb was transplanted from the non-perspective to a perspective twin. Healing took place without immunosuppression with satisfactory function; six years after the procedure was the

limb shorter by 6.5 cm. The range of motion in the hip and knee was appropriate; there was difficult plantar and dorsal flexion of the foot[107, 108].

CONCLUSION

The desire and need of every individual to achieve physical completeness and perfection accompanies the whole human history and it is one of the most important human needs. Surgical methods to fulfil this desire led from reconstruction through replantation and microsurgical transfers up to allogeneous transplantations.

Reconstructive transplantation is a clinical reality. Operations have been performed in various countries in the whole world; totally there were about 180 performed. Basically all complications of immunosuppression and surgical technique occurred. Serious complications and failure occurred in approximately 21 cases. According to available data, three patients after complex transplantations – four limbs simultaneously in one case and both hands together with face in two cases died; another two died after facial transplant. Furthermore, several patients died due to indirect complications, mainly generalization of the original malignant tumour.

Most frequently is transplanted the dominant hand or both hands, followed by the face. Other transplantations are rather rare. Allogeneous transplantation after almost twenty years of uncertainty and disputes gained its place in the spectrum of procedures in reconstructive plastic surgery. It is still an exceptional procedure, performed in specialized centres and remains reserved for a very narrow group of severely disabled and highly motivated patients. The original scepticism and refusal clearly moved towards interest and acceptation, mainly based on achieved results from the actual patients who underwent the transplantation. The method is still not a routine and there remain several specific questions to be answered, mainly concerning the long-term functional results, transplantation in children or in oncological patients.

The risks of immunosuppressive therapy are the greatest problem in these transplantations due to severe adverse effects, mainly the possibility of malignant tumours and opportunistic infections and it is the strongest argument of the opponents. The advocates claim that even kidney or pancreatic transplant is not a life saving procedure and it is only based on the will of the patients, whether they want to proceed with the therapy after thorough information about the risks. In spite of ethical disputes among lay and expert community are these procedures performed, patients after surgery report positive feedback in vast majority. The question whether these procedures should be performed or not is currently being replaced by the questions how to perform it the best and safe.

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REFERENCES

1. www.handtransplant.com
2. www.handregistry.com
3. Alcorn JB. Memorandum. Use of VCA Grafts to Reconstruct the Abdominal Wall. January 13, 2015. Available from: http://optn.transplant.hrsa.gov/media/1159/vca_abdominal_wall_memo.pdf
4. Lanzetta M. – personal communication
5. Klapheke MM, Marcell C, Taliaferro G, Creamer B. Psychiatric assessment of candidates for hand transplantation. *Microsurgery*. 2000;20(8):453–7.
6. Klapheke M. Transplantation of the human hand: psychiatric considerations. *Bull Menninger Clin*.1999;63:159–173
7. Furr LA, Wiggins O, Cunningham M, Vasilic D, Brown CS, Banis JC Jr, Maldonado C, Perez-Abadia G, Barker JH.P sychosocial implications of disfigurement and the future of human face transplantation. *Plast Reconstr Surg*. 2007 Aug;120(2):559–65.
8. Zhang LC, Zhao YB, Hu WL. Ethical issues in penile transplantation. *Asian J Androl.* 2010 Nov;12(6):795–800.
9. Agich GJ, Siemionow M. Until they have faces: the ethics of facial allograft transplantation. *J Med Ethics*. 2014 Dec;115(6):333–42.
10. Barker JH, Furr A, McGuire S, Cunningham M, Wiggins O, Banis JC Jr. On the ethics of composite tissue allotransplantation (facial transplantation). *Plast Reconstr Surg.* 2007 Apr 15;119(5):1621–2.
11. Tobin GR, Breidenbach WC, Klapheke MM, Bentley FR, Pidwell DJ, Simmons PD. Ethical considerations in the early composite tissue allograft experience: a review of the Louisville Ethics Program. *Transplant Proc*. 2005 Mar;37(2):1392–5.
12. Clarke A, Simmons J, White P, Withey S, Butler PE. Attitudes to face transplantation: results of a public engagement exercise at the Royal Society Summer Science Exhibition. *J Burn Care Res*. 2006 May-Jun;27(3):394–8.
13. Mathes DW, Schlenker R, Ploplys E, Vedder N. A survey of North American hand surgeons on their current attitudes toward hand transplantation. *J Hand Surg Am.* 2009 May–Jun;34(5):808–14.
14. Mathes DW, Kumar N, Ploplys E. A survey of North American burn and plastic surgeons on their current attitudes toward facial transplantation. *J Am Coll Surg*. 2009 Jun;208(6):1051–8.e3.
15. Kiwanuka H, Bueno EM, Diaz-Siso JR, Sisk GC, Lehmann LS, Pomahac B. Evolution of ethical debate on face transplantation. *Plast Reconstr Surg*. 2013 Dec;132(6):1558–68.
16. Cendales L, Hardy MA. Immunologic considerations in composite tissue transplantation: overview. *Microsurgery*. 2000;20(8):412–9.
17. Barnes PJ. Anti-inflammatory actions of glucocorticoids: molecular mechanisms. Clin Sci (Lond). 1998 Jun;94(6):557–72.
18. Ransom JT. Mechanism of action of mycophenolate mofetil. *Ther Drug Monit.* 1995 Dec;17(6):681–4.
19. Clipstone NA, Crabtree GR. Calcineurin is a key signaling enzyme in T lymphocyte activation and the target of the immunosuppressive drugs cyclosporin A and FK506. *Ann N Y Acad Sci.* 1993 Nov 30;696:20–30.
20. Hewitt CW, Black KS, Fraser LA, Howard EB, Martin DC, Achauer BM, Furnas DW. Composite tissue (limb) allografts in rats. I. Dose-dependent increase in survival with cyclosporine. *Transplantation*. 1985 Apr;39(4):360–4.
21. Black KS, Hewitt CW, Fraser LA, Howard EB, Martin DC, Achauer BM, Furnas DW. Composite tissue (limb) allografts in rats. II. Indefinite survival using low-dose cyclosporine. *Transplantation*. 1985 Apr;39(4):365–8.
22. European Multicentre Trial Group [No authors listed]. Cyclosporin in cadaveric renal transplantation: one-year follow-up of a multicentre trial. *Lancet*. 1983 Oct 29;2(8357):986–9.
23. Hricik DE, O'Toole MA, Schulak JA, Herson J. Steroid-free immunosuppression in cyclosporine-treated renal transplant recipients: a meta-analysis. *J Am Soc Nephrol.* 1993 Dec;4(6):1300–5.
24. Sehgal SN. Rapamune (RAPA, rapamycin, sirolimus): mechanism of action immunosuppressive effect results from blockade of signal transduction and inhibition of cell cycle progression. *Clin Biochem*. 1998 Jul;31(5):335–40.
25. Lee WP, Yaremchuk MJ, Pan YC, Randolph MA, Tan CM, Weiland AJ. Relative antigenicity of components of a vascularized limb allograft. *Plast Reconstr Surg*. 1991 Mar;87(3):401–11.

26. Duquesnoy RJ. Is histocompatibility testing needed for composite tissue transplantation? *Transplant Proc.* 1998 Sep;30(6):2724–8.
27. Billingham R, Brendt L. Quantitative studies on tissue transplantation immunity. IV. Induction of tolerance in newborn mice and studies on the phenomenon of runt disease. *Philos Trans R Soc. Lond Biol Sci.* 1959;242:439
28. Mathes DW, Randolph MA, Solari MG, Nazzal JA, Nielsen GP, Arn JS, Sachs DH, Lee WP. Split tolerance to a composite tissue allograft in a swine model. *Transplantation.* 2003 Jan 15;75(1):25–31.
29. Schneeberger S, Gorantla VS, Hautz T, Pulikkottil B, Margreiter R, Lee WP. Immunosuppression and rejection in human hand transplantation. *Transplant Proc*. 2009 Mar;41(2):472–5.
30. Medical Tribune-World Wide report. Transplant is successful with a cadaver forearm. *Med Trib Med News* 1964; 5 (20): 1,38.
31. Zion's Story: The Gift of hands. Available from: www.chop.edu/stories/zions-story-gift-hands#.VorgYrbhBkg
32. Lanzetta M, Perani D, Anchisi D, Rosén B, Danna M, Scifo P, Fazio F, Lundborg G. Early use of artificial sensibility in hand transplantation. *Scand J Plast Reconstr Surg Hand Surg*. 2004;38(2):106–11.
33. Pomahac B. – personal communication
34. Pomahac B, Pribaz JJ, Bueno EM, Sisk GC, Diaz-Siso JR, Chandawarkar A, Westvik TS, Malin EW, Eriksson E. Novel surgical technique for full face transplantation. *Plast Reconstr Surg.* 2012 Sep;130(3):549–55.
35. Pomahac B, Bueno EM, Sisk GC, Pribaz JJ. Current principles of facial allotransplantation: the Brigham and Women's Hospital Experience. Plast Reconstr *Surg.* 2013 May;131(5):1069–76.
36. Soga S, Pomahac B, Wake N, Schultz K, Prior RF, Kumamaru K, Steigner ML, Mitsouras D, Signorelli J, Bueno EM, Enterline DS, Rybicki FJ. CT angiography for surgical planning in face transplantation candidates. *AJNR Am J Neuroradiol*. 2013 Oct;34(10):1873–81.
37. Gharb BB, Rampazzo A, Kutz JE, Bright L, Doumit G, Harter TB. Vascularization of the facial bones by the facial artery: implications for full face allotransplantation. *Plast Reconstr Surg*. 2014 May;133(5): 1153–65.
38. Fischer S, Kueckelhaus M, Pauzenberger R, Bueno EM, Pomahac B. Functional outcomes of face transplantation. *Am J Transplant*. 2015 Jan;15(1):220–33.
39. Petruzzo P, Kanitakis J, Testelin S, Pialat JB, Buron F, Badet L, Thaunat O, Devauchelle B, Morelon E. Clinicopathological Findings of Chronic Rejection in a Face Grafted Patient. *Transplantation*. 2015 Dec;99(12):2644–50.
40. Carty MJ, Hivelin M, Dumontier C, Talbot SG, Benjoar MD, Pribaz JJ, Lantieri L, Pomahac B. Lessons learned from simultaneous face and bilateral hand allotransplantation. *Plast Reconstr Surg*. 2013 Aug;132(2):423–32.
41. Khalifian S, Brazio PS2, Mohan R2, Shaffer C2, Brandacher G3, Barth RN4, Rodriguez ED5. Facial transplantation: the first 9 years. *Lancet.* 2014 Dec 13;384(9960):2153–63.
42. Buncke HJ, Hoffman WY, Alpert BS, Gordon L, Stefani AE. Microvascular transplant of two free scalp flaps between identical twins. *Plast Reconstr Surg.* 1982 Nov;70(5):605–9.
43. Jiang HQ, Wang Y, Hu XB, Li YS, Li JS. Composite tissue allograft transplantation of cephalocervical skin flap and two ears. *Plast Reconstr Surg*. 2005 Mar;115(3):31e–35e.
44. Butler PEM. Composite tissue allograft transplantation of cephalocervical skin flap and two ears. *Plast Reconstr Surg*. 2005 Mar;115(3):discussion 36e–37e.
45. ABC News. Doctors in Texas perform historic skull and scalp transplant surgery [Internet]. Available from: http://www.abc.net.au/news/2015-06-05/doctors-perform-historic-skull-and-scalp-transplant-surgery/6524056
46. Buiret G, Rabilloud M, Combe C, Paliot H, Disant F, Céruse P. Larynx transplantation: laryngectomees´ opinion poll. *Transplantation.* 2007 Dec 27;84(12):1584–9.
47. Anthony JP, Argenta P, Trabulsy PP, Lin RY, Mathes SJ. The arterial anatomy of larynx transplantation: microsurgical revascularization of the larynx. *Clin Anat*. 1996;9(3):155–9.
48. Strome M, Wu J, Strome S, Brodsky G. A comparison of preservation techniques in a vascularized rat laryngeal transplant model. *Laryngoscope.* 1994 Jun;104(6 Pt 1):666–8.
49. Marie JP. Human Bilateral Laryngeal Reinnervation: *Implications for Transplantation*. Phoenix, AZ: American Laryngeal Association; 2009.
50. Marie JP, Dehesdin D, Ducastelle T, Senant J. Selective reinnervation of the abductor and adductor muscles of the canine larynx after recurrent nerve paralysis. *Ann Otol Rhinol Laryngol*. 1989 Jul;98:530–6.
51. van Lith-Bijl JT, Mahieu HF. Reinnervation aspects of laryngeal transplantation. *Eur Arch Otorhinolaryngol*. 1998;255(10):515–20.
52. Kluyskens P, Ringoir S. Follow-up of a human larynx transplantation. *Laryngoscope*. 1970 Aug;80(8):1244–50.
53. Strome M, Stein J, Esclamado R, Hicks D, Lorenz RR, Braun W, Yetman R, Eliachar I, Mayes J. Laryngeal transplantation and 40-month follow-up. *N Engl J Med.* 2001 May 31;344(22):1676–9.
54. Monaco AP. Transplantation of the larynx--a case report that speaks for itself. *N Engl J Med.* 2001 May 31;344(22):1712–4.
55. Tintinago L, White A, Lopez B, Casas C. Trasplante de laringe y tráquea superior como opción terapéutica en trauma laringotraqueal irreparable. *Acta Otorrinolaringol Cir Cabeza Cuello.* 2002;30 Suppl 4:102–109.
56. Farwell DG, Birchall MA, Macchiarini P, Luu QC, de Mattos AM, Gallay BJ, Perez RV, Grow MP, Ramsamooj R, Salgado MD, Brodie HA, Belafsky PC. Laryngotracheal transplantation: technical modifications and functional outcomes. *Laryngoscope*. 2013 Oct;123(10):2502–8.
57. Jo HK, Park JW1, Hwang JH1, Kim KS1, Lee SY1, Shin JH2. Risk acceptance and expectations of laryngeal allotransplantation. *Arch Plast Surg.* 2014 Sep;41(5):505–12.
58. Rose KG, Sesterhenn K, Wustrow F. Tracheal allotransplantation in man. *Lancet*. 1979 Feb 24;1(8113):433.
59. Levashov YuN, Yablonsky PK, Cherny SM, Orlov SV, Shafirovsky BB, Kuznetzov IM. One-stage allotransplantation of thoracic segment of the trachea in a patient with idiopathic fibrosing mediastinitis and marked tracheal stenosis. *Eur J Cardiothorac Surg.* 1993;7(7):383–6.
60. Herberhold C, Stein M, von Falkenhausen M. Long-term results of homograft reconstruction of the trachea in childhood. *Laryngorhinootologie.* 1999 Dec;78(12):692–6.
61. Jacobs JP, Quintessenza JA, Andrews T, Burke RP, Spektor Z, Delius RE, Smith RJ, Elliott MJ, Herberhold C. Tracheal allograft reconstruction: the total North American and worldwide pediatric experiences. *Ann Thorac Surg*. 1999 Sep;68(3):1043–51; discussion 1052.
62. Klepetko W, Marta GM, Wisser W, Melis E, Kocher A, Seebacher G, Aigner C, Mazhar S. Heterotopic tracheal transplantation with omentum wrapping in the abdominal position preserves functional and structural integrity of a human tracheal allograft. *J Thorac Cardiovasc Surg*. 2004 Mar;127(3):862–7.
63. Delaere PR, Vranckx JJ, Meulemans J, Vander Poorten V, Segers K, Van Raemdonck D, De Leyn P, Decaluwé H, Dooms C, Verleden G. Learning curve in tracheal allotransplantation. *Am J Transplant*. 2012 Sep;12(9):2538–45.
64. Tintinago LF, Herrera DA, Medina E, Patiño JH, Cano F, Restrepo CS. Ultrasonographic evaluation of a vascularized tracheal transplantation. *J Ultrasound Med.* 2005 Aug;24(8):1145–9.
65. Birchall M. Tongue transplantation. Lancet. 2004 May 22;363(9422):1663.
66. Chi JJ, Haughey BH. Tongue Transplantation. *Curr Otorhinolaryngol Rep* 2014;2:178–183.
67. Dorafshar AH, Bojovic B, Christy MR, Borsuk DE, Iliff NT, Brown EN, Shaffer CK, Kelley TN, Kukuruga DL, Barth RN, Bartlett ST, Rodriguez ED. Total face, double jaw, and tongue transplantation: an evolutionary concept. *Plast Reconstr Surg*. 2013 Feb;131(2):241–51.
68. The world's first composite transplantation of neck organs carried out by a Polish team. [Internet] May 2015. Available from: http://losangeles.msz.gov.pl/en/c/MOBILE/news/the_world_s_first_composite_transplantation_of_neck_organs_carried_out_by_a_polish_team_

69. Polish doctors perform rare, extensive throat transplant. [Internet] May 2015. Available from: http://www.nydailynews.com/life-style/health/polish-doctors-perform-rare-throat-transplant-article-1.2209664
70. Levi DM, Tzakis AG, Kato T, Madariaga J, Mittal NK, Nery J, Nishida S, Ruiz P. Transplantation of the abdominal wall. *Lancet*. 2003 Jun 28;361(9376):2173–6.
71. Cipriani R, Contedini F, Santoli M, Gelati C, Sgarzani R, Cucchetti A, Lauro A, Pinna AD. Abdominal wall transplantation with microsurgical technique. Am J *Transplant*. 2007 May;7(5):1304–7.
72. Giele H, Bendon C, Reddy S, Ramcharan R, Sinha S, Friend P, Vaidya A. Remote revascularization of abdominal wall transplants using the forearm. *Am J Transplant*. 2014 Jun;14(6):1410–6.
73. Ravindra KV, Martin AE, Vikraman DS, Brennan TV, Collins BH, Rege AS, Hollenbeck ST, Chinappa-Nagappa L, Eager K, Cousino D, Sudan DL. Use of vascularized posterior rectus sheath allograft in pediatric multivisceral transplantation--report of two cases. *Am J Transplant*. 2012 Aug;12(8):2242–6.
74. Agarwal S, Dorafshar AH, Harland RC, Millis JM, Gottlieb LJ. Liver and vascularized posterior rectus sheath fascia composite tissue allotransplantation. *Am J Transplant*. 2010 Dec;10(12):2712–6.
75. Selvaggi G, Levi DM, Cipriani R, Sgarzani R, Pinna AD, Tzakis AG. Abdominal wall transplantation: surgical and immunologic aspects. *Transplant Proc*. 2009 Mar;41(2):521–2.
76. Tietze A. Ersatz des resecierten unteren radiusendes durch eine grosszehenphalange Vehr Etsch Ges Chir Einunddreissigster Congress 1902;1:77.
77. Lexer E. Joint transplantation and arthroplasty. *Surg Gynecol Obstet*. 1925;40:782–809.
78. Volkov M. Allotransplantation of joints. *J Bone Joint Surg Br*. 1970, Feb;52(1):49–53.
79. Doi K, Akino T, Shigetomi M, Muramatsu K, Kawai S. Vascularized bone allografts: review of current concepts. *Microsurgery*. 1994;15(12):831–41.
80. Hofmann GO, Kirschner MH. Clinical experience in allogeneic vascularized bone and joint allografting. *Microsurgery*. 2000;20(8):375–83.
81. Diefenbeck M, Wagner F, Kirschner MH, Nerlich A, Mückley T, Hofmann GO. Outcome of allogeneic vascularized knee transplants. *Transpl Int*. 2007 May;20(5):410–8.
82. Cavadas PC, Thione A, Carballeira A, Blanes M. Bilateral transfemoral lower extremity transplantation: result at 1 year. *Am J Transplant*. 2013 May;13(5):1343–9.
83. Hu W, Lu J, Zhang L, Wu W, Nie H, Zhu Y, Deng Z, Zhao Y, Sheng W, Chao Q, Qiu X, Yang J, Bai Y. A preliminary report of penile transplantation: part 2. *Eur Urol*. 2006 Nov;50(5):1115–6; discussion 1116.
84. Hu W, Lu J, Zhang L, Wu W, Nie H, Zhu Y, Deng Z, Zhao Y, Sheng W, Chao Q, Qiu X, Yang J, Bai Y. A preliminary report of penile transplantation. *Eur Urol*. 2006 Oct;50(4):851–3.
85. BBC News. South Africans perform first 'successful' penis transplant. [Internet] March 2015. Available from: http://www.bbc.com/news/health-31876219
86. CNN News. First penis transplant patient's girlfriend is pregnant, doctor says. [Internet] June 2015. Available from: http://edition.cnn.com/2015/06/12/health/penis-transplant-south-africa-pregnancy/
87. McKay DB, Josephson MA. Pregnancy in recipients of solid organs--effects on mother and child. *N Engl J Med*. 2006 Mar 23;354(12):1281–93.
88. Wranning CA, Akhi SN, Diaz-Garcia C, Brännström M. Pregnancy after syngeneic uterus transplantation and spontaneous mating in the rat. *Hum Reprod*. 2011 Mar;26(3):553–8.
89. Díaz-García C, Akhi SN, Wallin A, Pellicer A, Brännström M. First report on fertility after allogeneic uterus transplantation. *Acta Obstet Gynecol Scand*. 2010 Nov;89(11):1491–4.
90. Erman Akar M, Ozkan O, Aydinuraz B, Dirican K, Cincik M, Mendilcioglu I, Simsek M, Gunseren F, Kocak H, Ciftcioglu A, Gecici O, Ozkan O. Clinical pregnancy after uterus transplantation. *Fertil Steril*. 2013 Nov;100(5):1358–63.
91. Brännström M, Johannesson L, Bokström H, Kvarnström N, Mölne J, Dahm-Kähler P, Enskog A, Milenkovic M, Ekberg J, Diaz-Garcia C, Gäbel M, Hanafy A, Hagberg H, Olausson M, Nilsson L. Livebirth after uterus transplantation. *Lancet*. 2015 Feb 14;385(9968):607–16.
92. Jones TR, Humphrey PA, Brennan DC. Transplantation of vascularized allogeneic skeletal muscle for scalp reconstruction in renal transplant patient. *Transplant Proc*. 1998 Sep;30(6):2746–53.
93. Peacock EE Jr, Madden JW. Human composite flexor tendon allografts. *Ann Surg*. 1967 Oct;166(4):624-9.
94. Asencio G, Abihaidar G, Leonardi C. Human composite flexor tendon allografts. A report of two cases. *J Hand Surg Br*. 1996 Feb;21(1):84–8.
95. Gimberteau JC. Ten years follow-up of two cases of vascularized digital flexor system allotransplantation. In *Composite tissue allografts* (ed. Dubernard JM) Paris: John Libbey Eurotext 2001:41–42.
96. Robertson A, Nutton RW, Keating JF. Current trends in the use of tendon allografts in orthopaedic surgery. *J Bone Joint Surg Br*. 2006 Aug;88(8):988–92.
97. Albert E. *Wien Med Presse*. 1885;26:1285
98. Mackinnon SE, Hudson AR. Clinical application of peripheral nerve transplantation. *Plast Reconstr Surg*. 1992 Oct;90(4):695–9.
99. Mackinnon SE, Doolabh VB, Novak CB, Trulock EP. Clinical outcome following nerve allograft transplantation. *Plast Reconstr Surg*. 2001 May;107(6):1419–29.
100. Carpenter JP, Tomaszewski JE. Immunosuppression for human saphenous vein allograft bypass surgery: a prospective randomized trial. *J Vasc Surg*. 1997 Jul;26(1):32–42.
101. O'Bichere A, Shurey S, Sibbons P, Green C, Phillips RK. Experimental model of anorectal transplantation. *Br J Surg*. 2000 Nov;87(11):1534–9.
102. Galvão FH, Waisberg DR, De Mello Vianna RM, De Castro Galvão R, Seid VE, Andraus W, Chaib E, D'Albuquerque LA. Intestinal transplantation including anorectal segment in the rat. *Microsurgery*. 2012 Jan;32(1):77–9.
103. Araki J, Mihara M, Narushima M, Iida T, Sato T, Koshima I. Vascularized anal autotransplantation model in rats: preliminary report. *Transplant Proc*. 2011 Nov;43(9):3552–6.
104. Araki J, Nishizawa Y, Sato T, Naito M, Akita K, Tashiro K, Iida T, Koshima I. Anorectal transplantation in human cadavers: mock anorectal allotransplantation. *PLoS One*. 2013 Jul 11;8(7):e68977.
105. Malaysia baby gets transplanted arm of her twin sister. Daily News [Internet]. December 2000. Available from: http://www.hurriyetdailynews.com/malaysia-baby-gets-transplanted-arm-of-her-twin-sister.aspx?pageID=438&n=malaysia-baby-gets-transplanted-arm-of-her-twin-sister-2000-06-12
106. Baby given tragic sister's arm. Daily Mail [Internet]. Available from: http://www.dailymail.co.uk/health/article-5503/Baby-given-tragic-sisters-arm.html 107. Zuker RM, Redett R, Alman B, Coles JG, Timoney N, Ein SH.First successful lower-extremity transplantation: technique and functional result. *J Reconstr Microsurg*. 2006 May;22(4):239–44.
108. Fattah A, Cypel T, Donner EJ, Wang F, Alman BA, Zuker RM. The first successful lower extremity transplantation: 6-year follow-up and implications for cortical plasticity. *Am J Transplant*. 2011 Dec;11(12):2762–7.

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TRACHEAL ALLOTRANSPLANTATION AND REGENERATION

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ACTA CHIRURGIAE PLASTICAE, 57, 1, pp. 29-38

SUMMARY

Non-malignant and malignant obstruction of the tracheal airway causes significant morbidity and mortality. With increased use of artificial airways, benign and iatrogenic complications are increasing. A tracheal stenosis that is less than 5 cm in length can be resected with end-to-end anastomosis. Longer tracheal lesions can be treated in a palliative way by placement of a stent to secure airway lumen patency. The management of tracheal defects is an evolving field. Tracheal transplantation and tracheal regeneration may provide major treatment advances to cases with long-segment tracheal involvement. This review examines the current possibilities and future prospects in the area of tracheal transplantation and regeneration.

KEYWORDS

Trachea, allotransplantation, revascularization, immunosuppression, regeneration

INTRODUCTION

The trachea is one of the few organs that are exceptionally difficult to transplant because of the technical difficulty to restore the blood supply to the graft. The blood supply of the 12 cm-long trachea depends in its entirety on small blood vessels branching out into numerous even smaller vessels, each of them subsequently penetrating the trachea in between the cartilage rings to provide blood supply to segments of the mucosal lining. If a part of the trachea is removed from the airway, all blood supply is interrupted. The removed part of the trachea cannot survive, even if it was to be placed straightaway back into the airway. Our group has a 20-year long research record in the field of tracheal revascularization and holds a leading position in the development of tracheal transplantation by means of vascularized segmental units.

A tracheal transplant may be necessary to repair surgical defects of the laryngotracheal airway tract that are unsuitable for segmental resection and autologous tissue repair. With the exception of some anecdotal, poorly documented cases performed without blood supply restoration[1] or immunosuppressive medication[2], no clinical tracheal allotransplants have been transplanted orthotopically as an isolated composite tissue graft. In tracheal allotransplantation, it is important to deal with both immunosupression and indirect revascularization in a heterotopic position. The first documented preserved viability of a heterotopically revascularized allotransplant was published by Klepetko et al. in 2004[3]. The graft was revascularized in the omentum of a patient who underwent lung transplantation from the same donor. Ultimately, the trachea transplant was not used, but its viability was documented for at least 60 days. The first documented revascularized tracheal allotransplant to be reported was published in 2010[4].

Our approach to tracheal heterotopic revascularization, orthotopic transplantation, and withdrawal of immunosuppressive medication is based on a series of six cases[5]. For tracheal allotransplantation, we consider a "good match" to mean that the donor is of the same blood group as the patient.

SURGICAL TECHNIQUE

Revascularization of the trachea is the first step towards successful tracheal transplantation. The typical arterial and venous blood supply, consisting of several small tracheo-esophageal branches, does not enable direct tracheal transplantation. Currently, the only reliable way to achieve tracheal revascularization is to wrap the isolated avascular trachea with a well-vascularized soft tissue flap perfused by a vascular pedicle, which then allows transfer of the revascularized trachea to an airway defect. The forearm fascia flap pedicled on the radial artery and vein has proven to be reliable for tracheal revascularization[5]. The forearm skin is incised and dissected away from the underlying fascia and subcutaneous tissue. After removal of the membranous part, the trachea is wrapped with the radial forearm fascia and the forearm skin flaps are sutured to the incised trachea. It is important to ensure complete immobility between the trachea and the surrounding recipient's vascular bed to obtain a fast revascularization of the blood vessels of the tracheal adventitia (Fig. 1). It usually occurs within three – four days.

Revascularization has to be achieved by the outgrowth of capillary buds from the fascia flap (recipient blood vessels) connecting with those within the adventitia (donor blood vessels) of the tracheal segment (Fig. 2). Inosculation is the establishment of direct vascular anastomoses between the vascularized soft tissue flap and the adventitia of the trachea.

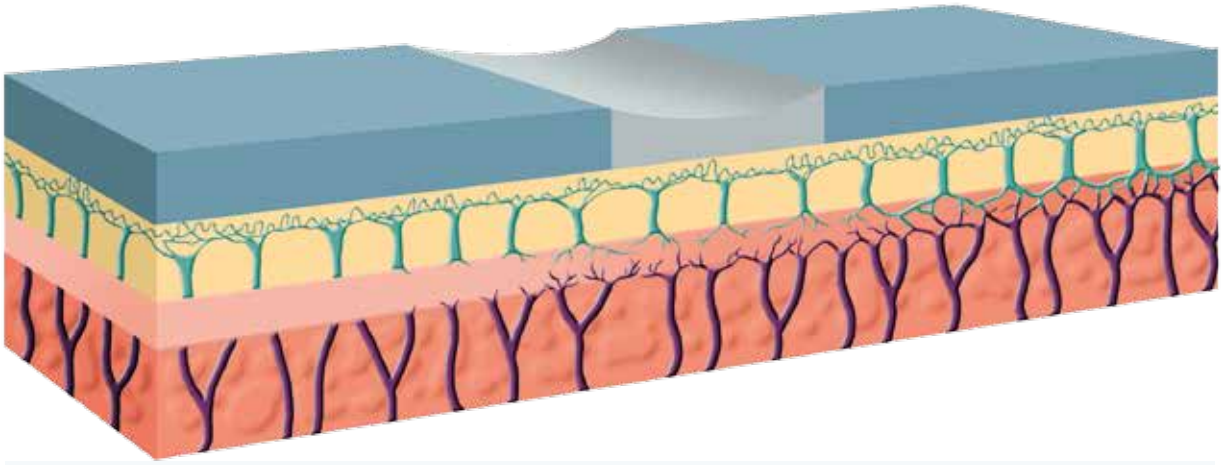

Fig. 1. Revascularisation of allogeneic trachea occurs within 3–4 days by a connection between the vessels of the donor and recipient

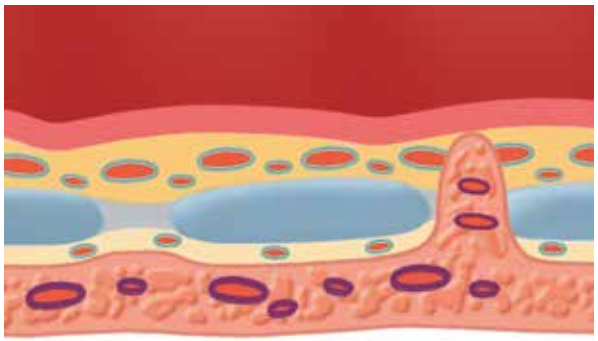

Fig. 2. Revascularization achieved by the outgrowth of capillary buds from the fascia flap (recipient blood vessels) connecting with those in the adventitia (donor blood vessels) of the tracheal segment

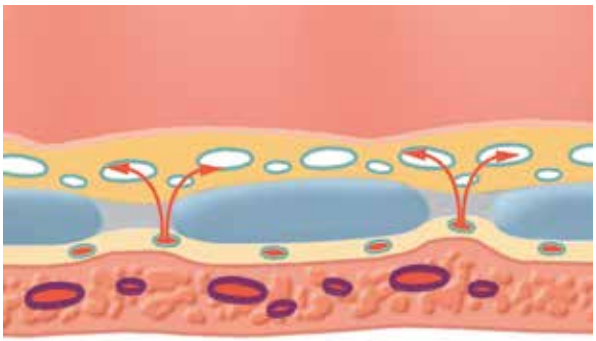

Fig. 3. Revascularization of the mucosal layer of an avascular tracheal segment occurs through the intercartilaginous ligaments

Compared to a free skin graft, there are two additional barriers to revascularization for a tracheal allograft. The cartilage rings and intercartilaginous ligaments may interfere with the revascularization of the mucosal lining of the cartilaginous trachea. Cartilaginous tissue does not allow for the ingrowth of blood vessels. Revascularization of the mucosal layer of an avascular tracheal segment occurs through the intercartilaginous ligaments (Fig. 3). Full revascularization and mucosal regeneration of the cartilaginous trachea can be achieved within 2–4 months of the trachea being implanted in the forearm. In our initial patient series of tracheal transplantations, it became clear that the intercartilaginous ligaments formed an obstruction for the ingrowth of native blood vessels. The placement of intercartilaginous incisions at the time of forearm implantation was an important adaptation. The incisions of the intercartilaginous ligaments facilitated revascularization, enabling the ingrowth of recipient vessels into the submucosal space of the transplant. When incisions through the intercartilaginous ligaments were made at regular intervals, full revascularization and mucosal regeneration of the cartilaginous allotransplant could be obtained in a shorter period of time. Incision of the intercartilaginous ligaments will accelerate the revascularization process by bringing the recipient blood vessels closer to the submucosal capillaries (Fig. 4).

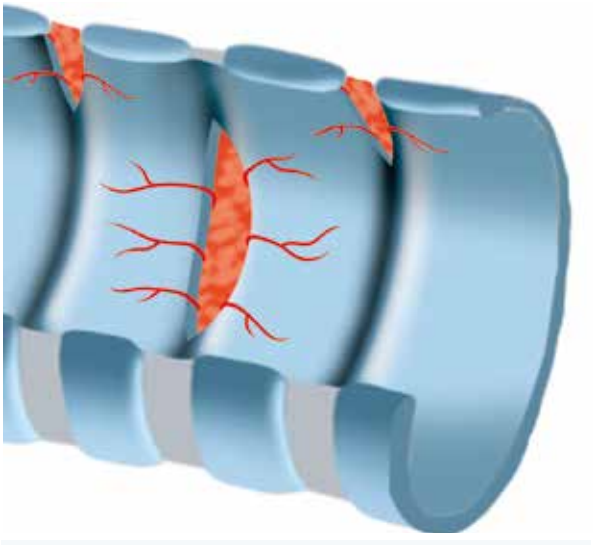

Fig. 4. Incision of the intercartilaginous ligaments facilitates the revascularization process by bringing the recipient blood vessels closer to the submucosal capillaries

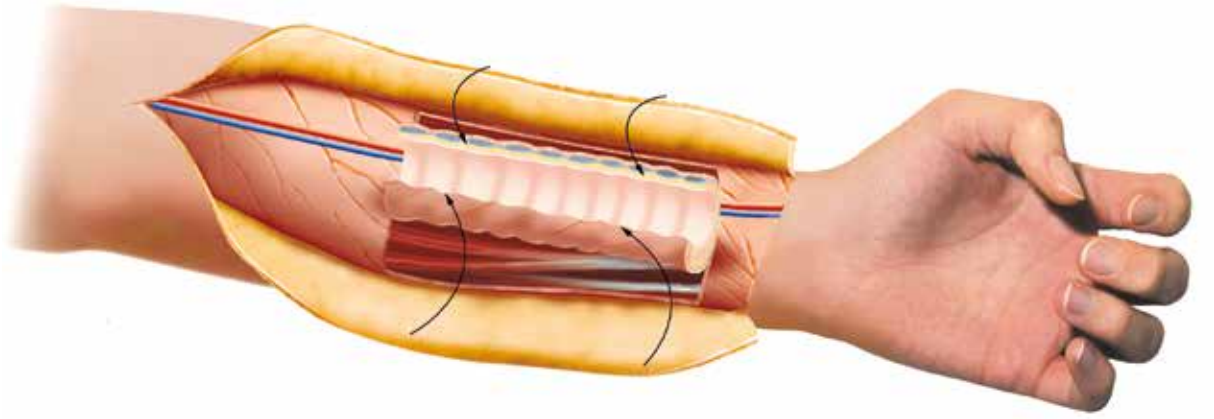

Fig. 5. Tracheal allotransplant segment is implanted to the forearm and wrapped with well-vascularized antebrachial fascia and skin

The tracheal allotransplant is a composite tissue transplant that may be used to restore the airway, with the goal of improving quality of life. The benefits achieved by tracheal allotransplantation have to be balanced against the morbidity of long-term immunosuppression therapy. Immunosuppressive medication should be withdrawn before immunosuppressant-related complications occur. The cartilage tissue seems to escape immunologic rejection owing to the absence of blood vessels, and because the chondrocytes are protected within a matrix[4,6,7]. Regularly spaced intercartilaginous incisions provide routes for angiogenic recipient vessels to penetrate the ligamentous barrier and thus grow into the submucosal space of the transplant tissue after withdrawal of immunosuppressants.

CLINICAL EXAMPLES AND RESULTS

Eight transplants were used in 6 patients. Two of the initial transplants were lost after withdrawal of immunosuppressive therapy. Of the 6 patients treated so far, 5 patients were treated for a long-segment stenosis and 1 patient was transplanted to treat a long-segment laryngotracheal involvement by a chondrosarcoma. Two stage surgery – heterothopic allotransplantation and consequently orthotopic transplantation of a tracheal transplant to treat a long-segment (6 cm) airway stenosis is described as an example of our technique.

An eight cm long tracheal allotransplant is implanted to the forearm and wrapped with well-vascularized antebrachial fascia and skin (Fig. 5). During the first weeks the luminal site of the transplant is protected by the application of fibrin glue. After revascularization, a buccal mucosa graft from the recipient can be applied to the midportion of the transplant for replacement of donor mucosa and this allows safe withdrawal of immunosuppressive drugs (Fig. 6). A mucosal defect is created in the central part of the transplant and the midportion is grafted with a full-thickness mucosal graft from the recipient's buccal area. The surviving recipient mucosal graft also allows secondary healing of the areas of donor epithelial lining that underwent necrosis. The recipient's long-segment tracheal stenosis is incised longitudinally. After full revascularization and mucosal

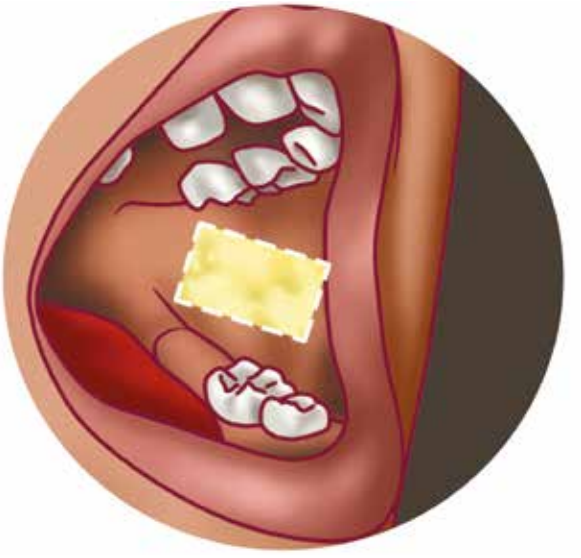

Fig. 6. A buccal mucosa graft from the recipient is harvested and is applied to the midportion of the tracheal allotransplant

regeneration have been achieved (Fig. 7), the tracheal allotransplant is transplanted from the forearm to the airway defect on a radial vascular pedicle (Fig. 8). The radial blood vessels are sutured to the neck vessels to facilitate revascularization. The cartilaginous trachea is sutured into the airway defect to restore the concavity of the airway lumen. Withdrawal of immunosuppressive therapy can start one year after orthotopic transplantation.

Tracheal allotransplantation was also used in the treatment of a patient with an extended laryngotracheal chondrosarcoma. The patient was a 63-year-old man. The tumor developed over a period of more than 10 years. His airway could be preserved by the placement of a silicone stent. Due to the stagnation of secretions, he required periodical bronchoscopic cleaning of the stent. Since the last time, he had developed several acute episodes of stent blockages, which made definitive treatment necessary. The potential

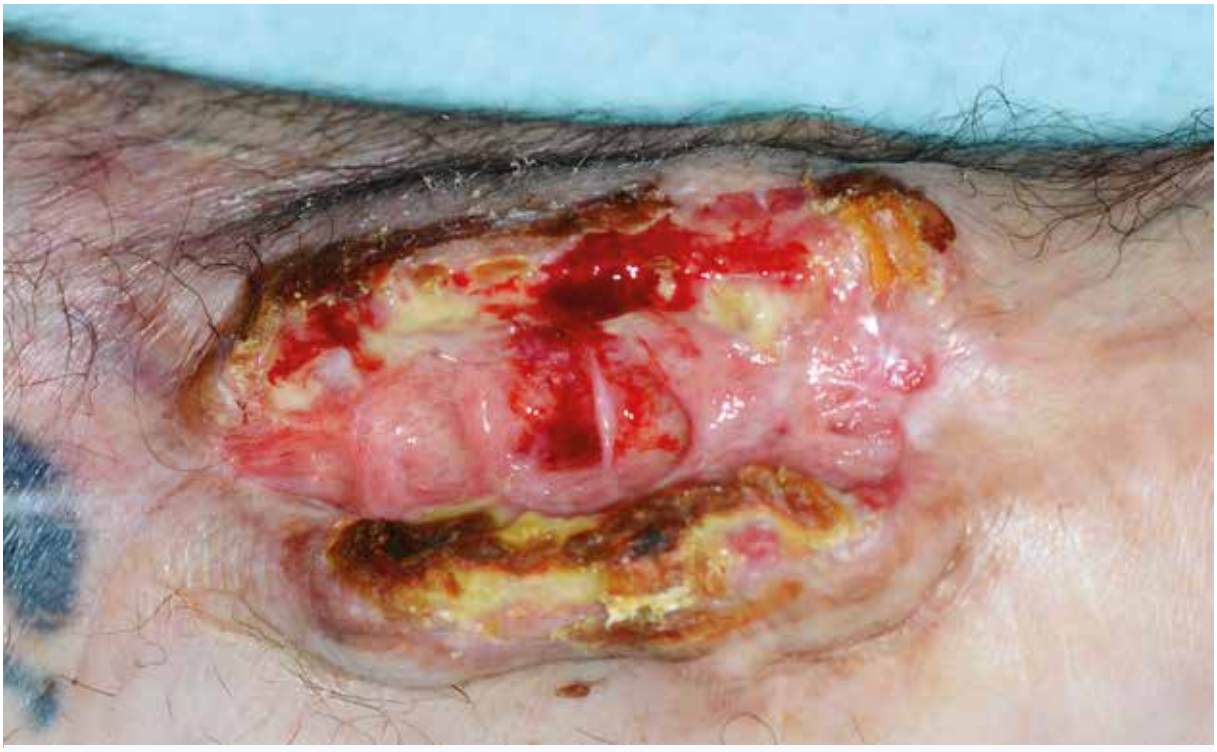

Fig. 7. Clinical picture of revascularized tracheal allotransplant with mucosal regeneration on the forearm

for tumor progression while under immunosuppression for a low-grade malignancy was considered to be low and was confirmed by CT scan at the time of orthotopic transplantation, which demonstrated a nearly unchanged tumor mass. Three months after implantation of a suitable allograft in the left forearm, the tumor was resected through an anterior cervical incision with a sternotomy extension and the tracheal allotransplant was used to repair the laryngotracheal defect. The lengths of the tracheal resection were 9 cm (right) and 6 cm (left side). Immunosuppressive medication was gradually withdrawn between 15 and 18 months after orthotopic transplantation. The transplant's morphology remained intact after withdrawal of immunosuppressive therapy. It seems that the mucosal repopulation of the transplant after cessation of immunosuppressants can occur with minimal loss of airway lumen.

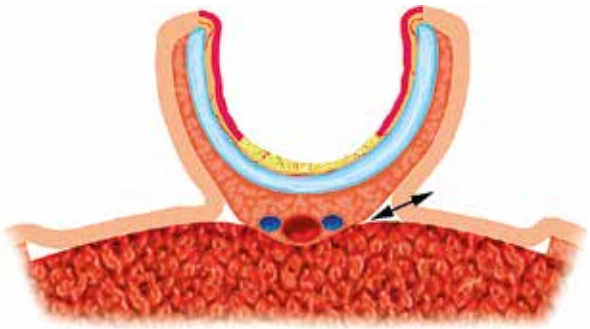

Fig. 8. After full revascularization and mucosal graft take (yellow mucosal part), the tracheal allotransplant remains viable on radial vascular pedicle and can be transplanted from the forearm to the airway defect

DISCUSSION

The relative contribution of tissue regeneration versus scarring in the healing of the airway mucosal lining depends on the extent of injury inflicted. A superficial epithelial wound can heal by way of regeneration of the surface epithelium[8]. Indeed tissues with a high proliferative capacity, such as airway tract epithelia, renew themselves continuously and, after injury, can regenerate above the basal membrane as long as the stem cells in these tissues have not been destroyed.

If a tissue injury is severe and involves damage of both epithelial cells and the submucosal layer, healing cannot be accomplished by regeneration alone. Under these conditions, the main healing process is repair by deposition of collagen, causing the formation of a scar. Future therapies should aim to promote regeneration and reduce scar tissue formation when dealing with full-thickness mucosal tracheal defects. Research of the potential use of stem cells for true regenerative healing is ongoing. The present challenge for regenerative medicine is to overcome the barriers to regeneration of the mucosal and epithelial lining in full-thickness epithelial defects. However, regeneration of full-thickness mucosal defects is not yet possible.

Tracheal segments destruction shorter than 5 cm may be treated by segmental resection. Post-intubation airway

stenosis and malignant tumors are the two most common indications to perform a surgical resection of a part of the trachea.

Definitive prosthetic replacement of the airway wall is not possible. The internal side of the airway tract belongs to the outside world and bacterial contamination of the prosthetic's internal surface prevents its usage as a definite solution.

The tracheal replacement is however necessary for longer partial or circumferential defects. Tracheal allotransplantation can be used but it is impossible to perform it directly using a single vascular pedicle due to irregular, segmental blood supply of tracheal wall. The native blood vessels are too small for microvascular anastomosis and the blood supply comes from several small sources. Tracheoesophageal branches from the inferior thyroid artery supply the upper half of the trachea. The bronchial arteries provide consistent blood supply to the carina and lowermost trachea. The best option seems to be the heterothopic transplantation of avascularised trachea into a well-nourished tissue bed and secondary orthotopic transplantation to the tracheal defect on the neck. The protocol for circumferential allotransplantation may be based on a bilateral transplantation of the cartilaginous trachea. The full length of the trachea and main bronchi can be used for allotransplantation. Two cartilaginous tracheal segments may be implanted at two forearm sites. By suturing the two allotransplants together, a tube may be created for circumferential airway repair. The first transplant is used to restore the posterior and lateral walls of the airway. A part of the forearm skin can be included as a temporary reconstruction of the anterior wall. In a second operation, the second transplant can be used to replace the forearm skin and to further augment the airway lumen.

Since 2008 the trachea has been called the first human organ that can be man-made using acellular natural or synthetic scaffold and stem cells.[9] De-vascularized native trachea was taken from deceased donor. As a first step towards a presumed stem-cell engineered regenerated trachea, a detergent was used to destroy all viable cells, leaving a scaffold of connective tissue. It was hypothesized that stem cells penetrate the connective tissue and subsequently cartilage, blood vessels and respiratory mucosa. This presumed regenerated trachea was implanted without restoration of any blood supply. It was also hypothesized that stem cell-mediated re-cellularization of a synthetic scaffold may also lead to a fully regenerated trachea that can be transplanted inside the airway.

Meanwhile an engineered trachea has been implanted in several patients. This achievement has received a lot of attention in medical journals as well as in the press. Indeed, the engineered windpipe was seen to be the first step towards other forms of organ regeneration. Classic organ transplantations with their typical side effects due to anti-rejection medication could then be replaced by growing organs from the body's own cells. However, the optimism surrounding organ regeneration has proved to be completely unfounded. In fact, the engineered trachea is an example of obvious scientific deception.

The engineered trachea was represented as a regenerated trachea after applying bone marrow cells to a de-cellularized[10] or synthetic scaffold[11]. There is no scientific foundation whatsoever to assume why stem cells would support airway tissue regeneration in this setting. In addition, even if a trachea-like organ would be generated, it would irrefutably fail after implantation if adequate blood supply had not been restored. As expected, the implantation of de-cellularized and synthetic scaffolds resulted in extremely high morbidity and mortality rates[12]. At this point in time, this form of airway regeneration should be regarded as hypothetical and scientifically unfounded[13,14,15].

CONCLUSION

Partial or circumferential airway repair may be necessary after long intubation, neck injury or resection of malignant tumors. Tracheal allotransplantation seems to be an option but still there are a lot of questions that have to be resolved before this becomes a routine technique. Tracheal allotransplantation at the time of tumor resection will be possible only for low-grade malignancies and not for other malignant tumors, because of the risk of tumor progression in the 3-month period of pretransplant immunosuppression. A circumferential defect left by tumor resection can be reconstructed temporarily with a stent wrapped in vascularized tissue. This type of reconstruction must be considered temporary due to inevitable stent-related complications. Tracheal allotransplantation may be considered in those patients with a temporary repair who remain tumor-free.

As a conclusion, tracheal transplantation can be safely performed in selected cases after heterotopic revascularization. Important are the partial incisions of the intercartilaginous ligaments for advancing the revascularization process and for safe withdrawal of immunosuppressive therapy. Growth factors may eventually be used for speeding up the revascularization process.

Declaration of interest: Author has no financial or other interests related to the content of the article.

REFERENCES

1. Levashov YuN, Yablonsky PK, Cherny SM, Orlov SV, Shafirovsky BB, Kuznetzov IM. One-stage allotransplantation of thoracic segment of the trachea in a patient with idiopathic fibrosing mediastinitis and marked tracheal stenosis. *Eur J Cardiothorac Surg*. 1993;7(7):383–6.
2. Rose KG, Sesterhenn K, Wustrow F. Tracheal allotransplantation in man. *Lancet*. 1979 Feb 24;1(8113):433.
3. Klepetko W, Marta GM, Wisser W, Melis E, Kocher A, Seebacher G, Aigner C, Mazhar S. Heterotopic tracheal transplantation with omentum wrapping in the abdominal position preserves functional and structural integrity of a human tracheal allograft. *J Thorac Cardiovasc Surg*. 2004 Mar;127(3):862–7.
4. Delaere P, Vranckx J, Verleden G, De Leyn P, Van Raemdonck D; Leuven Tracheal Transplant Group. Tracheal allotransplantation after withdrawal of immunosuppressive therapy. *N Engl J Med*. 2010 Jan 14;362(2):138–45.
5. Delaere PR, Vranckx JJ, Meulemans J, Vander Poorten V, Segers K, Van Raemdonck D, De Leyn P, Decaluwé H, Dooms C, Verleden G. Learning curve in tracheal allotransplantation. *Am J Transplant*. 2012 Sep;12(9):2538–45.
6. Sykes M. Immune evasion by chimeric trachea. N Engl J Med. 2010 Jan 14;362(2):172–4.
7. Delaere PR, Vranckx JJ, Den Hondt M; Leuven Tracheal Transplant Group. Tracheal allograft after withdrawal of immunosuppressive therapy. *N Engl J Med*. 2014 Apr 17;370(16):1568–70.
8. Puchelle E, Zahm JM. Repair process of the airway epithelium. In: Lenfant

C, Dekker M, editors. *Airway environment: from injury to repair*. Series: Lung biology in health and diseases. New York: Marcel Dekker; 1996. pp. 1576–1582.
9. Macchiarini P, Jungebluth P, Go T, Asnaghi MA, Rees LE, Cogan TA, Dodson A, Martorell J, Bellini S, Parnigotto PP, Dickinson SC, Hollander AP, Mantero S, Conconi MT, Birchall MA. Clinical transplantation of a tissue-engineered airway. *Lancet*. 2008 Dec 13;372(9655):2023–30.
10. Elliott MJ, De Coppi P, Speggiorin S, Roebuck D, Butler CR, Samuel E, Crowley C, McLaren C, Fierens A, Vondrys D, Cochrane L, Jephson C, Janes S, Beaumont NJ, Cogan T, Bader A, Seifalian AM, Hsuan JJ, Lowdell MW, Birchall MA. Stem-cell-based, tissue engineered tracheal replacement in a child: a 2-year follow-up study. *Lancet*. 2012 Sep 15;380(9846):994–1000.
11. Jungebluth P, Alici E, Baiguera S, Blomberg P, Bozóky B, Crowley C, Einarsson O, Gudbjartsson T, Le Guyader S, Henriksson G, Hermanson O, Juto JE, Leidner B, Lilja T, Liska J, Luedde T, Lundin V, Moll G, Roderburg C, Strömblad S, Sutlu T, Watz E, Seifalian A, Macchiarini P. Tracheobronchial transplantation with a stem-cell-seeded bioartificial nanocomposite: a proof-of-concept study. *Lancet*. 2011 Dec 10;378(9808):1997–2004.
12. Vogel G. Trachea transplants test the limits. *Science*. 2013 Apr 19;340(6130):266–8.
13. Cyranoski D. Investigations launched into artificial tracheas. *Nature*. 2014 Dec 4;516(7529):16–7.
14. Delaere PR, Van Raemdonck D. The trachea: the first tissue-engineered organ? *J Thorac Cardiovasc Surg*. 2014 Apr;147(4):1128–32.

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PULMONARY EMBOLISM AFTER ABDOMINOPLASTY – ARE WE REALLY ABLE TO AVOID ALL COMPLICATIONS? CASE REPORTS AND LITERATURE REVIEW

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ACTA CHIRURGIAE PLASTICAE, 57, 1, pp. 35-38

SUMMARY

Pulmonary embolism is a potentially lethal complication in plastic surgery patients. About 34% of the members of American Society of Plastic Surgery have diagnosed pulmonary embolism in their patients, and 7% had experienced at least 1 death due to this complication. The American Society of Plastic Surgeons Executive Committee approved the Venous Thromboembolism Task Force Report. The members agreed that there was not enough evidence to make all-inclusive recommendations for plastic surgery deep vein thrombosis and pulmonary embolism prophylaxis, but released the 2005 Caprini Scale accompanied by the Task Force recommendations for use in plastic surgery. It is generally strongly advised to use appropriate prophylactic measures against venous thromboembolism in all surgical procedures. However, even then we cannot completely avoid this serious complication.

KEYWORDS

Abdominoplasty, pulmonary embolism, prophylaxis

INTRODUCTION

Venous thromboembolism (VTE) and pulmonary embolism (PE) is a serious and potentially lethal complication in plastic surgery patients. VTE is the second most common complication after discharge from the hospital, the second most common cause of extended stay in hospital and the third most common cause of both – excess mortality and financial costs[1]. In the United Kingdom it is estimated that about 25,000 deaths each year are caused by hospital acquired thrombosis[2]; in the United States the estimation is about 100,000–200,000 deaths annually[3,4]. It was also reported that about 18,000 cases of VTE are reported in plastic surgery patients in the United States each year[5]. Ten per cent of patients die within the first hour after clinical manifestation of PE, survivors can be stigmatized by right ventricular dysfunction and even failure[6]; 40%–80% of patients with VTE develop a post-thrombotic syndrome between 5–10 years after VTE that is associated with worsened quality of life predominantly due to chronic venous ulcerations[7].

The study from 2007 reported that 40% from 596 ASPS surgeons have experienced DVT and 34% have diagnosed PE during their practice. Those numbers are surprisingly and alarmingly high. Seven per cent reported at least 1 patient death due to a postoperative PE[8]. Systematic review of literature found that among the body contouring plastic surgery cases the most risky procedure with regards to VTE is circumferential body lift (3.40%), followed by abdominoplasty combined with an intraabdominal procedure (2.17%), then abdominoplasty with concomitant plastic surgery (0.79%) and finally abdominoplasty alone (0.35%)[9].

Venous thromboembolism starts most often intraoperatively with usually small nidus that can grow over the next couple of days and then propagate. It usually happens under appropriate conditions as a coincidence of risks factors and continuous limited mobility. The use of chemoprophylaxis, mechanical prophylaxis and early and active mobilization with other regimen precautions should minimize the risk of VTE and PE[10].

Based on the aforementioned facts, there was a special guideline for prevention of VTE and PE elaborated and introduced into practice from 2012 at the Department of plastic surgery, Hospital Na Bulovce in Prague. This guideline adopted the risk scale list from acknowledged standards for prevention and treatment of VTE and PE recommended for use in general surgery in the Czech Republic[11]. The risk of VTE is evaluated in every patient admitted to the hospital and appropriate preventive measures are taken. These

measures include regimen precautions (early mobilisation, hydration, rehabilitation, smoking prohibition, cessation or elimination of risk hormonal therapy if possible), mechanical prevention (lower leg bandage or elastic socks, sequential compressive system) and chemoprophylaxis (enoxaparine, nadroparine or bemiparine). Despite the aforementioned precautions we have experienced two unexpected cases of pulmonary embolism in young patients with minimal risk ratio that we would like to present in the following case reports.

CASE REPORTS

Case Report 1

Nineteen-year-old female healthy patient was admitted for abdominoplasty with liposuction. No hormonal contraception or other medication was ascertained, BMI was 25. According to the scale only 1 point of risk was accounted and only regimen and mechanical prevention was recommended. However, the operating surgeon considered abdominoplasty with liposuction as an independent risk factor therefore also enoxaparine 0.2 ml per day was used, starting the evening before surgery. Liposuction 1000 ml of pure fat was performed followed by standard abdominoplasty with muscle tightening. 500 g of tissue was removed and surgery took 2 hours and 5 minutes. Postoperative period was uneventful; the patient was fully mobilized first day postoperatively and discharged on day 5 after surgery. Pulmonary embolism occurred 7 days after discharge and 12 days after the surgery. Embolism was demonstrated by CT angiography, with 2 cm diameter obstruction of the right main pulmonary artery and right bronchopneumonia, D-dimers were slightly elevated. PE was successfully treated, no heart impairment was confirmed using repeated echocardiography, however the patient has been complaining of mild dyspnoea after physical exercising. Complete haematological examination including molecular-genetic tests, Factor V Leiden, Factor II Prothrombin, Glycoprotein IV, Prothrombin activator inhibitor etc. was done with no pathology or gene mutation. The patient is currently treated with rivaroxaban (Xarelto, Bayer Pharma AG, Berlin, Germany).

Case Report 2

A 37-year-old female patient was admitted to hospital for abdominoplasty with wide diastasis of approx. 10 cm and small umbilical hernia. Hormonal contraception (Provera) was in use; the patient had a substitution therapy after thyreoidectomy. BMI of this patient was 26. One risk point was found and adequate measures were taken - regimen precautions and elastic stockings. Abdominoplasty with T scar was performed with muscle tightening and umbilical hernia repair; the surgery took 2 hours. No complications were noted in the postoperative period; the patient was again fully mobilized on day one after the surgery and discharged on day 3. Pulmonary embolism occurred 9 days after discharge and 12 days after the surgery. Embolism was demonstrated by CT angiography (embolization to the artery for pulmonary segment S7, S8, S10 on the right side, pulmonary infarction on the right side and bilateral pleuropneumonia). D-dimers were significantly elevated. Embolization was successfully treated. Again, no pathology or mutation was found in complete haematological survey. The patient stays under warfarinum natricum therapy (Warfarin Orion, Orion Corporation, Espoo, Finland) and still reports overall weakness and breathing discomfort.

DISCUSSION

VTE and PE have been reported after simple abdominoplasty in 0.35%, and in abdominoplasty with simultaneous plastic surgery in 0.79%[9]. The increased risk of VTE when liposuction is added to excision body contouring surgery was reported but did not reach statistical significance[12,13]. More current review reports VTE in simple abdominoplasty without chemoprophylaxis between 0.04%–20% while incidence is 0%[14] when chemoprophylaxis is used. In 2012 Raulo reported the results from a survey of 110,000 interventions from 440 surgeons. DVT in abdominoplasty occurred in 0.9%[15]. Abdominoplasty is definitely reported to be the plastic surgery procedure most often associated with DVT ant PE. Association of VTE or PE with abdominoplasty may be related to the interference with venous drainage from the legs and pelvis. Superficial venous network can be affected directly by the surgery; deep venous flow can suffer from increased intra-abdominal pressure after muscle tightening and indirectly by using special compressive garment[16]. Prolonged general anaesthesia with decline in peripheral resistance and limited ability of postoperative mobilisation can be an important additive factors too[12].

The risk factors for DVT and PE in general surgery and orthopaedic patients were identified during the last decades and scoring system to evaluate the individual patient risk was introduced to clinical practice. This scoring system does not only assess the risk of DVT and PE, but also, according to the relevant risk, offers an optimal management to prevent this event. In 1998, the board of directors of the American Society of Plastic Surgeons initiated the task force on deep vein thrombosis. It based its recommendations on guidelines published by the American College of Chest Physicians. However, the data reviewed did not include plastic surgery procedures and patients[17]. Therefore most plastic and aesthetic surgeons adopted the recommendations and standards from general surgery. In 2009, Venturi et al published their guidelines and recommendations for prevention of venous trombembolism in plastic surgery patients. They ascertained and modified the American College of Chest Physicians guidelines from 2008[18]. However, a considerable effort to overcome the lack of valid guidelines for plastic surgery can be clearly seen in the last years. In 2008, the Plastic Surgery Foundation (PSF) Research Oversight Committee identified the DVT risk stratification and prevention as a top patient safety research priority in plastic surgery specialty. The Venous Thromboembolism Prevention Study (VTEPS) was set up by PSF and at the same year it was demonstrated that post-operative inpatient enoxaparine reduces 60-day rates of symptomatic VTE without changing rates of hematoma[19]. In July 2011 the American Society of Plastic Surgeons Executive Committee approved the Venous Thromboembolism Task Force Report. Task Force members agreed that there was not enough evidence to make all-inclusive recommendations for plastic surgery prophylaxis medication, dosage or length of prophylaxis. The Task Force however released its full report: the 2005 Caprini Scale accompanied by the Task Force recommendations, patient venous thromboembolism risk self-assessor form and patient hand-out on venous thromboembolism signs and symptoms.

The risk of post-operative haematoma and bleeding are the main concerns expressed by plastic surgeons who do not use chemoprophylaxis[20]. This particular complication, while using LMWH, was reported in some studies[12,21,22]. Dini et al released the results of a prospective cohort study about safety of thromboprophylaxis in abdominoplasty that had to be suspended due to a high incidence of large haematomas and even wound dehiscence. However, they used rivaroxaban that is not primarily intended for general perioperative thromboprophylaxis and was approved by FDA for this purpose only for total hip and knee replacement surgery[23]. On the contrary, no higher risk of postoperative haematoma when using chemoprophylaxis was reported by several other studies[19,20,24]. The most important concern to consider is that PE is a potentially lethal complication and we should tolerate some higher risk of bleeding than the risk of massive PE[10]. At the Department of Plastic Surgery Hospital na Bulovce we adopted and strictly follow standards recommended for general surgery in the Czech Republic[10] in accordance with the recommendations of the Czech Society for Haemostasis and Thrombosis.

The most common form of VTE is deep venous thrombosis (DVT) and the typical signs include oedema - often asymmetric, leg pain and tenderness, sensation of tension in the calf, change of skin colour, slightly increased temperature. Pulmonary embolism clinically presents by increased temperature, tachycardia, drop of blood pressure, chest pain, difficulty breathing and cough[5]. It is however accepted that only 33% of DVT cases present with symptoms[25] and most of them are silent without any discomfort. In both our patients the main clinical sign of pulmonary embolism was atypical intensive back pain and overall weakness that might have postponed slightly the correct diagnosis in the first case. However, in the second case that followed shortly after the first one, this diagnosis was considered first.

The risk of DVT and PE is the highest at the time of limited mobilisation during surgery or close to it. After complete mobilisation of the patient the risk become steadily lower. It was however reported that venous thromboembolism risk may remain elevated for up to 90 days after a surgery. According to a study done on 947,454 middle aged women in the United Kingdom, women were 70 times more likely to be admitted for venous thromboembolism in the first six weeks after an inpatient operation and 10 times more likely after a one-day surgery compared with those not having surgery. The risk was lower but still substantially increased 7–12 weeks after the surgery. This pattern of risk was similar for pulmonary embolism and deep venous thrombosis[26]. Yale et al developed a model to determine the risk of DVT in the post-hospitalization period. Univariate and multivariate logistic regression analyses were used to identify risk variables related to DVT. Within 60 days after discharge from a hospital was DVT the reason of a new admission to hospital in 93.2% in high risk patients, 52.9% in moderate risk patients and 12.0% in low risk patients[27]. In both our cases the risk score according to the risk assessment questionnaire was 1. We are aware of the role of immobilisation and prolonged risky period for DVT and PE. Both our patients were fully mobilized and have had rehabilitation focusing on self-care and breathing after abdominoplasty from the first day after the surgery. The risk of PE decreases at the time after surgery and was less expected, especially in low risk patients. PE occurred in both our patients 12 days after the surgery, 11 days after full mobilisation and 7 or 9 days after discharge to home care. The length of stay in hospital greater or equal to 4 days was recognized as an independent risk factor for DVT[28]. This may be an additive risk factor for our first patient who was discharged on the 5th post-operative day.

The age of the patients was shown to be an additive risk factor in the development of DVT and PE. Patients over 40 years old are in greater risk of both complications compared with younger patients with risk approximately doubling in every decade[29,30]. Both our patients were younger than 40 years (19 and 37 years).

The duration of chemoprophylaxis has been discussed, however it is recommended that prophylaxis to be continued only until the patient with low and moderate risk is discharged from the hospital. In high-risk patients, the chemoprophylaxis should be prolonged for 7–10 days. Prolonged chemoprophylaxis is – according to our standard – used in patients with a risk score equal or more than 6. Our patients were at low risk and prophylactic measures were discontinued at the day of discharge from the hospital.

Education of patients about the signs of DVT is very important for their cooperation and acceptance of preventative measures and also to recognise early signs of this complication. Sadideen et al reported that after introduction of the special questionnaire there was a dramatically significant improvement in the awareness of DVT (90% vs. 49%; P<0.01), its signs (80% vs. 50%; P<0.01) and preventive measures (84% vs. 39%; P<0.01) among the patients[31]. At our department each patient is educated about the DVT and PE at the time of admission to the hospital.

CONCLUSION

The thromboembolic disease and pulmonary embolism is a potentially lethal complication of all surgeries, including reconstructive and aesthetic plastic surgical procedures. There are, however, prophylactic measures established to prevent this dangerous event. These are regimen precautions, mechanical support of blood flow and chemoprophylaxis. These measures can be employed separately or in combination, especially in high-risk patients. International or national standards for prevention of the DVT and PE should be strictly implemented to everyday practice at all surgical departments. But even then there is a possibility of this complication and sometimes in the most unlikely patients. It is our responsibility therefore to be aware of this complication and to consider seriously all, even atypical, signs of this complication.

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REFERENCES

1. Geerts WH, Bergqvist D, Pineo GF, Heit JA, Samama CM, Lassen MR, Colwell CW; American College of Chest Physicians.Prevention of venous thromboembolism. American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th Edition).*Chest*. 2008 Jun;133(6 Suppl):381S-453S. House of Commons Health Committee. *The prevention of Venous Thromboembolism in Hospitalised Patients*. 2nd Report. London: House of Commons, 2005.

2. Davison SP, Venturi ML, Attinger CE, Baker SB, Spear SL. Prevention of venous thromboembolism in the plastic surgery patient. *Plast Reconstr Surg.* 2004 Sep 1;114(3):43E–51E.
3. Murphy RX Jr, Alderman A, Gutowski K, Kerrigan C, Rosolowski K, Schechter L, Schmitz D, Wilkins E. Evidence-based practices for thromboembolism prevention: summary of the ASPS Venous Thromboembolism Task Force Report. *Plast Reconstr Surg*. 2012 Jul;130(1):168e–175e.
4. Young VL, Watson ME. The need for venous thromboembolism (VTE) prophylaxis in plastic surgery. *Aesthet Surg J*. 2006 Mar–Apr;26(2):157–75.
5. Kearon C. Natural history of venous thromboembolism. *Circulation.* 2003 Jun 17;107(23 Suppl 1):I22–30.
6. Kahn SR, Shbaklo H, Lamping DL, Holcroft CA, Shrier I, Miron MJ, Roussin A, Desmarais S, Joyal F, Kassis J, Solymoss S, Desjardins L, Johri M, Ginsberg JS. Determinants of health-related quality of life during the 2 years following deep vein thrombosis. *J Thromb Haemost*. 2008 Jul;6(7):1105–12. Broughton G, Rios JL, Rohrich RJ, Brown SA. Deep venous thrombosis prophylaxis practice and treatment strategies among plastic surgeons: Survey results. *Plast Reconstr Surg*. 2007;119(1):157–74.
7. Hatef DA, Trussler AP, Kenkel JM. Procedural risk for venous thromboembolism in abdominal contouring surgery: a systematic review of the literature. *Plast Reconstr Surg*. 2010 Jan;125(1):352–62.
8. Green D. VTE prophylaxis in aesthetic surgery patients. *Aesthet Surg J*. 2006 May–Jun;26(3):317–24.
9. Krska Z. Prevention of TEN in surgery, prolonged thromboprophylaxis. *Rozhl Chir.* 2012 May;91(5):256–61.
10. Hatef DA, Kenkel JM, Nguyen MQ, Farkas JP, Abtahi F, Rohrich RJ, Brown SA. Thromboembolic risk assessment and the efficacy of enoxaparin prophylaxis in excisional body contouring surgery. *Plast Reconstr Surg*. 2008 Jul;122(1):269–79.
11. Hughes CE 3rd. Reduction of lipoplasty risks and mortality: an ASAPS survey. *Aesthet Surg J.* 2001 Mar;21(2):120–7.
12. Clavijo-Alvarez JA, Rubin JP. Approach to venous thromboembolism prophylaxis: are we evolving fast enough in plastic surgery? *Ann Plast Surg*. 2011 Mar;66(3):306–9.
13. Raulo C, Samama CM, Benhamou D, Jeandel T. Prevention of operational thromboembolic risk in plastic and aesthetic surgery. Analysis of cases, inquiries of practice and recommendations of professional practices. *Ann Chir Plast Esthet*. 2012 Aug;57(4):373–9.
14. Most D, Kozlow J, Heller J, Shermak MA. Thromboembolism in plastic surgery. *Plast Reconstr Surg.* 2005 Feb;115(2):20e–30e.
15. McDevitt NB. Deep vein thrombosis prophylaxis. American Society of Plastic and Reconstructive Surgeons. *Plast Reconstr Surg*. 1999 Nov;104(6):1923–8.
16. Venturi ML, Davison SP, Caprini JA. Prevention of venous thromboembolism in the plastic surgery patient: current guidelines and recommendations. *Aesthet Surg J*. 2009 Sep–Oct;29(5):421–8.
17. Pannucci CJ, Bailey SH, Dreszer G, Fisher Wachtman C, Zumsteg JW, Jaber RM, Hamill JB, Hume KM, Rubin JP, Neligan PC, Kalliainen LK, Hoxworth RE, Pusic AL, Wilkins EG. Validation of the Caprini risk assessment model in plastic and reconstructive surgery patients. *J Am Coll Surg*. 2011 Jan;212(1):105–12.
18. Pannucci CJ, Wachtman CF, Dreszer G, Bailey SH, Portschy PR, Hamill JB, Hume KM, Hoxworth RE, Kalliainen LK, Rubin JP, Pusic AL, Wilkins EG. The effect of postoperative enoxaparin on risk for reoperative hematoma. *Plast Reconstr Surg*. 2012 Jan;129(1):160–8.
19. Seruya M, Venturi ML, Iorio ML, Davison SP. Efficacy and safety of venous thromboembolism prophylaxis in highest risk plastic surgery patients. *Plast Reconstr Surg*. 2008 Dec;122(6):1701–8.
20. Lemaine V, McCarthy C, Kaplan K, Mehrara B, Pusic AL, Cordeiro PG, Disa JJ. Venous thromboembolism following microsurgical breast reconstruction: an objective analysis in 225 consecutive patients using low-molecular-weight heparin prophylaxis. *Plast Reconstr Surg.* 2011 Apr;127(4):1399–406.
21. Dini GM, Ferreira MC, Albuquerque LG, Ferreira LM. How safe is thromboprophylaxis in abdominoplasty? *Plast Reconstr Surg.* 2012 Dec;130(6):851e–857e.
22. Reish RG, Damjanovic B, Colwell AS. Deep venous thrombosis prophylaxis in body contouring: 105 consecutive patients. *Ann Plast Surg*. 2012 Oct;69(4):412–4.
23. Dismuke SE, Wagner EH. Pulmonary embolism as a cause of death. The changing mortality in hospitalized patients. *JAMA*. 1986 Apr 18;255(15):2039–42.
24. Sweetland S, Green J, Liu B, Berrington de González A, Canonico M, Reeves G, Beral V; Million Women Study collaborators. Duration and magnitude of the postoperative risk of venous thromboembolism in middle aged women: prospective cohort study. *BMJ*. 2009 Dec 3;339:b4583.
25. Yale SH, Medlin SC, Liang H, Peters T, Glurich I, Mazza JJ. Risk assessment model for venothromboembolism in post-hospitalized patients. *Int Angiol.* 2005 Sep;24(3):250–4.
26. Pannucci ChJ, Dreszer G, Wachtman CHF, Bailey SH, Portschy PR, Hamill JB, Hume KM, Hoxworth RE, Rubin JP, Kaliainen LK, Pusic AL, Wilkisns EG. Postoperative Enoxaparin Prevents Symptomatic Venous Thromboembolism in High-Risk Plastic Surgery Patients. *Plast Reconstr Surg* 2011;128(5):1093–1103.
27. Anderson FA Jr, Wheeler HB, Goldberg RJ, Hosmer DW, Patwardhan NA, Jovanovic B, Forcier A, Dalen JE. A population-based perspective of the hospital incidence and case-fatality rates of deep vein thrombosis and pulmonary embolism. The Worcester DVT Study. *Arch Intern Med*. 1991 May;151(5):933–8.
28. Valente DS, Carvalho LA, Zanella RK, Valente S. Venous Thromboembolism following Elective Aesthetic Plastic Surgery: A Longitudinal Prospective Study in 1254 Patients. *Plast Surg Int.* 2014;2014:565–793.
29. Sadideen H, O'Callaghan JM, Navidi M, Sayegh M. Educating surgical patients to reduce the risk of venous thromboembolism: an audit of an effective strategy. *JRSM Short Rep*. 2011 Dec;2(12):97.

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USE OF OSTEOTOMY IN POST--TRAUMATIC DEFORMITY OF FRONTAL SINUS ANTERIOR WALL. CASE REPORT

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ACTA CHIRURGIAE PLASTICAE, 58, 1, 39-42

SUMMARY

Post-traumatic deformity of frontal sinus anterior table can be treated in various ways. Usage of a certain type of an implant is a common method. We performed an osteotomy and subsequent reduction of the fragments to reconstruct their anatomical position. Titanium miniplates and screws were used for fixation. This case report suggests a possible use of this method in patients with more extensive frontal sinus and distinct post-traumatic deformity. No similar case manages as described in our case report was found in the literature.

KEYWORDS

Frontal sinus, fracture, post-traumatic deformity, cranial osteotomy

INTRODUCTION

Frontal sinus fractures represent 5–15% of all maxillofacial injuries [1–3]. These fractures pose a long-term risk of facial deformity[4]. In addition, they may cause sinusitis, mucocele, meningitis, brain abscesses [4,5] and encephalitis [4]. Strong et al. report that isolated anterior table injuries account for 33% of frontal sinus fractures [1]. Gossman et al. describe 96 cases of frontal sinus injuries. Fifty percent of the fractures involved the anterior table of frontal sinus alone, and fifty percent involved both anterior and posterior tables [6].

Our patient with post-traumatic deformity of the anterior table of frontal sinus is presented in this case report.

CASE REPORT

A 35-year-old patient suffered an impressive fracture of the anterior table of frontal sinus, which was not primarily treated by surgery (Fig. 1a, b). Computed tomography (CT) scans performed after 3 months from the injury clearly showed a healed, impressive anterior table frontal sinus fracture (Fig. 2a, b). Under general anaesthesia, bicoronary access was used to expose the dislocated anterior table of frontal sinus, and a pericranial flap was prepared (Fig. 3a). We osteotomized the deformed part of the bone (using rotatory instruments), which was temporarily removed (Fig. 3b, c). Additional osteotomies were done in this bone fragment at the place of original fracture lines. Loose bone fragments were reduced to restore the original contour of the frontal bone. In our case, there were minimal gaps between the fragments, which did not require the addition of bone grafts. Titanium miniplates and screws were used for fixation (Fig. 3d). The osteosynthesis was covered with the pericranial flap, with subsequent skin closure. The wound was drained until the next day. Peri-operative antibiotic therapy was maintained for a period of 7 days. The patient healed without any complications. A good cosmetic effect was seen 5 months after the surgery (Fig. 4a, b). CT scans showed a satisfactory finding (Fig. 5a, b).

DISCUSSION

Calvarial vault defects may be repaired with autologous bone or alloplastic materials [7]. The main problem for the isolated anterior wall fractures is the aesthetic deformity of the forehead, which seldom causes functional complications [8].

Strong et al. performed a study in cadavers using endoscopic miniplate reduction of frontal sinus fractures. The success rate depended on fracture comminution. Furthermore, the authors used bone cement to camouflage the defect. The best results were achieved by augmentation with bone cement [1].

Strong used an endoscopic method to resolve isolated anterior table frontal sinus fractures above the orbital rim. The repair is generally performed 2 to 4 months after the injury when all forehead swelling has resolved. Porous polyethylene sheet was applied endoscopically and the fracture was camouflaged [5].

Arcuri et al. used a titanium mesh to treat post-traumatic deformity of anterior table frontal sinus. The implant was applied endoscopically [4].

Chen et al. used hydroxyapatite cement to reconstruct the post-traumatic frontal bone depression in 20 patients. The frontal bone was exposed through a bicoronal incision in the subperiosteal plane [9].

Duman et al. describe 12 cases where they used a porous polyethylene implant for reconstruction of contour and an-

terior wall defects of frontal bone. The time span between the trauma and reconstruction was 0–24 months [10].

There is a possibility to use a custom-made implant. These patient-specific alloplastic implants are used in larger craniofacial defects, which cause aesthetic and functional difficulties [11].

In our case, osteotomy of the broken part of the frontal sinus anterior table was performed, with subsequent reduction using fixation with titanium miniplates and screws. The surgery result provided a good effect. Bicoronary access is needed to expose the fracture as needed. A disadvantage of osteotomy can be seen in the opening of healed frontal sinus. The procedure provides the advantage of reconstructing the original shape and size of sinus without the need of augmentation or bridging the defect using an implant.

Since this is an isolated case, the risk of possible complications that may be associated with this procedure cannot be evaluated. No similar case managed as described above was found in literature. As reported by Altman, frontal sinus infection is rare in association with forehead reduction in feminization of the face. The feared complication of total loss of the anterior table due to bone resorption or infection seems to pose a negligible risk [12].

CONCLUSION

The described case indicates a potential use of this method in patients with more extensive frontal sinus and distinct post-traumatic deformity of frontal sinus anterior table. Osteotomy of frontal sinus anterior table represents an alternative management in these cases.

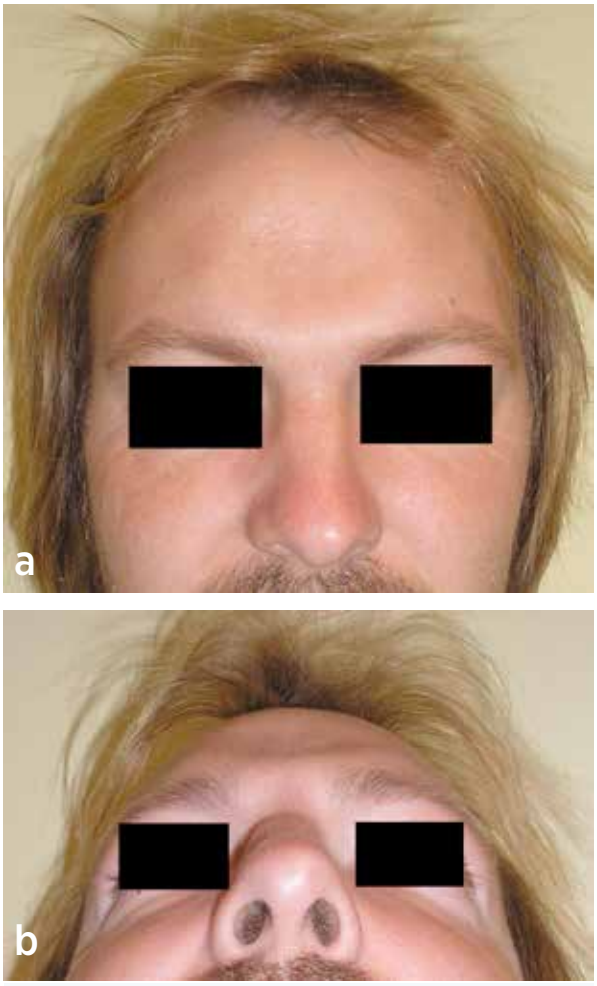

Fig. 1a, b. Post-traumatic deformity of frontal sinus anterior table

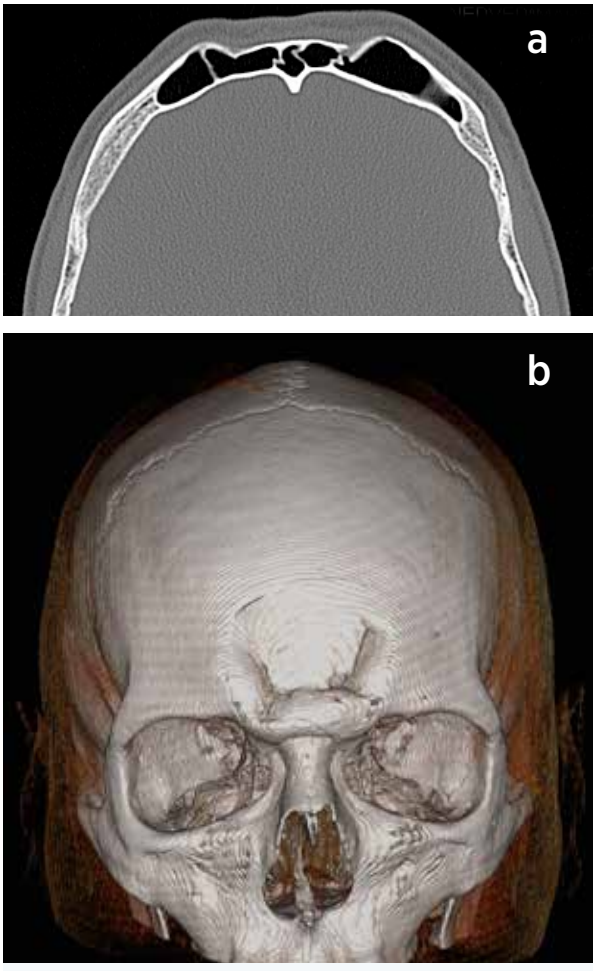

Fig. 2 a, b. Computed tomographic scan shows healed impressive fracture of frontal sinus anterior table

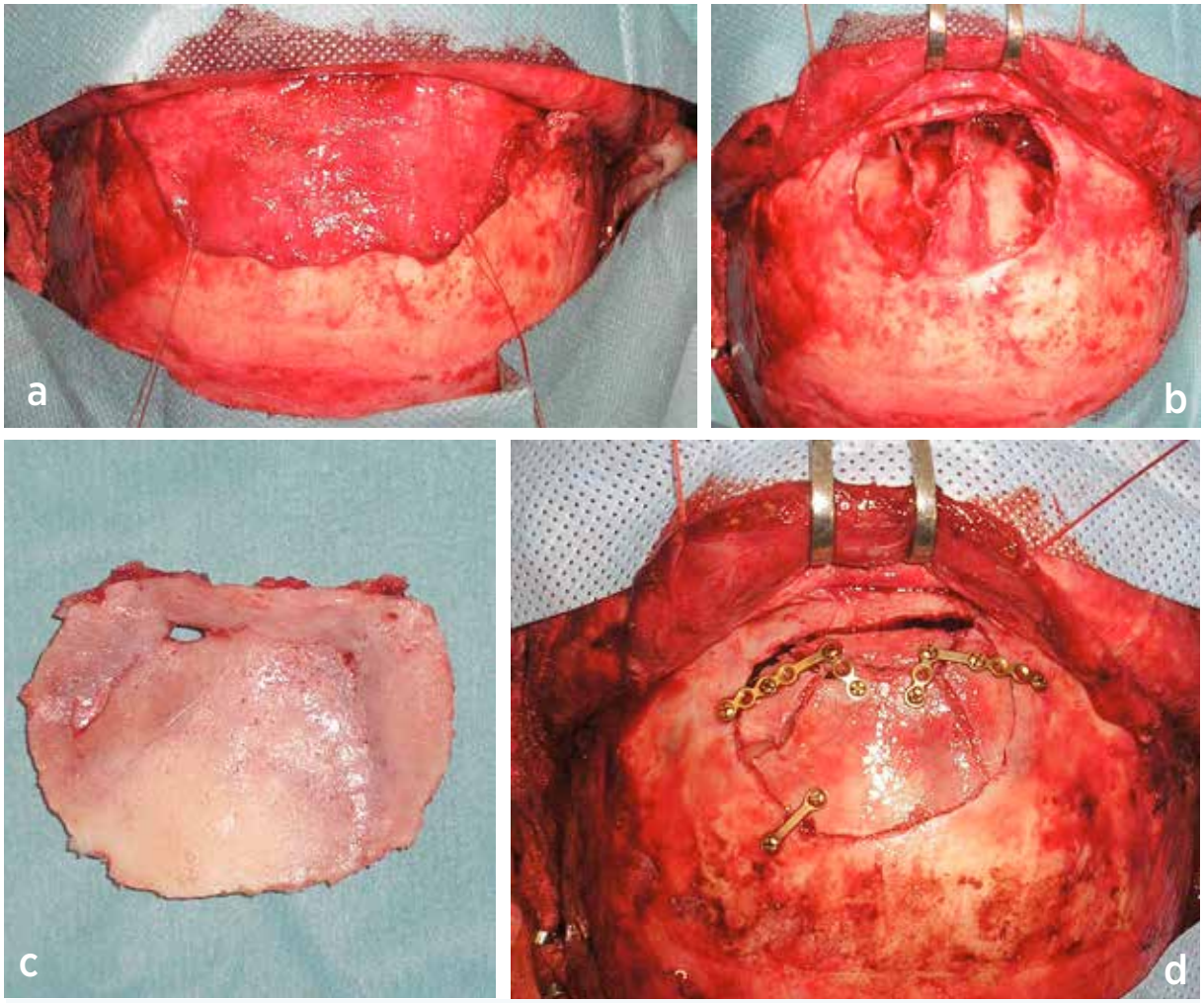

Fig. 3. Intraoperative photo: a – Prepared pericranial flap; b – Defect of frontal sinus anterior table after its osteotomy and temporary removal of the deformed part; c – Temporarily removed deformed bone fragment; d – Condition after bone fragment osteotomy along fracture lines, condition after reduction of the osteotomized parts and their fixation using titanium miniplates and screws

Fig. 4 a, b. Condition 5 months after the surgery

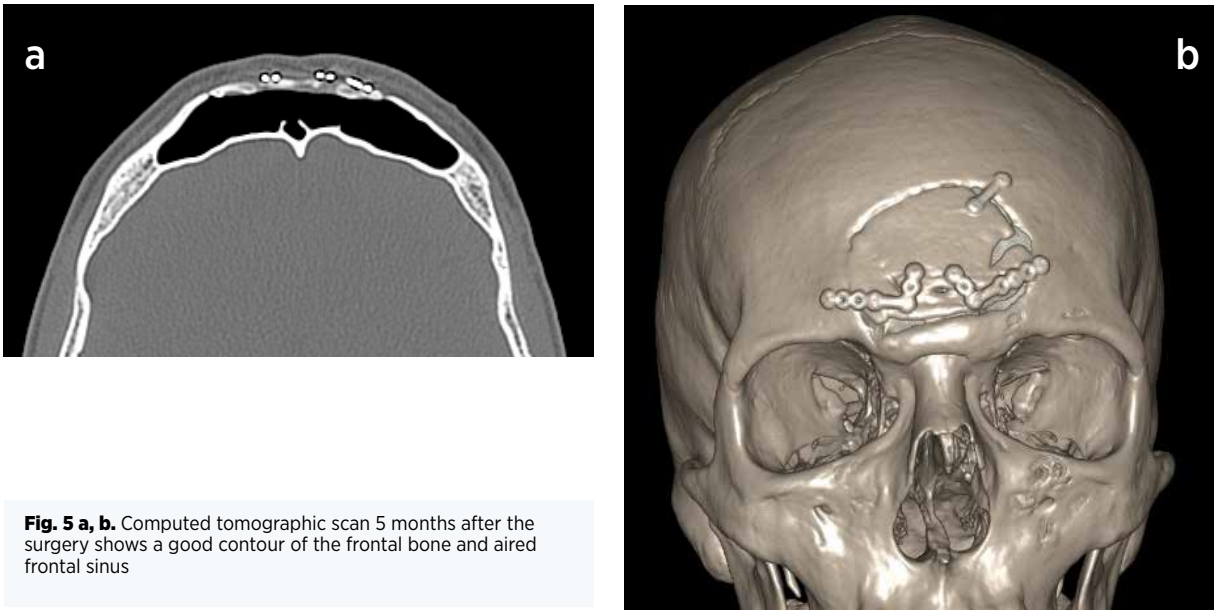

Fig. 5 a, b. Computed tomographic scan 5 months after the surgery shows a good contour of the frontal bone and aired frontal sinus

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REFERENCES

1. Strong EB, Buchalter GM, Moulthrop TH. Endoscopic repair of isolated anterior table frontal sinus fractures. *Arch Facial Plast Surg*. 2003;5:514–21.
2. Yavuzer R, Sari A, Kelly CP, Tuncer S, Latifoglu O, Celebi MC, Jackson IT. Management of frontal sinus fractures. *Plast Reconstr Surg*. 2005;115:79e-93e.
3. Dalla Torre D, Burtscher D, Kloss-Brandstätter A, Rasse M, Kloss F. Management of frontal sinus fractures – Treatment decision based on metric dislocation extent. *J Craniomaxillofac Surg*. 2014;42:1515–19.
4. Arcuri F, Baragiotta N, Poglio G, Benech A. Post-traumatic deformity of the anterior frontal table managed by the placement of a titanium mesh via an endoscopic approach. *Br J Oral Maxillofac Surg*. 2012;50:53e-4e.
5. Strong EB. Frontal sinus fractures: current concepts. *Craniomaxillofac Trauma Reconstr*. 2009;2:161–75.
6. Gossman DG, Archer SM, Arosarena O. Management of frontal sinus fractures: a review of 96 cases. *Laryngoscope*. 2006;116:1357–62.
7. Tieghi R, Consorti G, Clauser LC. Contouring of the forehead irregularities (washboard effect) with bone biomaterial. *J Craniofac Surg*. 2012;23:932-34.
8. Lee Y, Choi HG, Shin DH, Uhm KI, Kim SH, Kim CK, Jo DI. Subbrow approach as a minimally invasive reduction technique in the management of frontal sinus fractures. *Arch Plast Surg*. 2014;41:679–85.
9. Chen TM, Wang HJ, Chen SL, Lin FH. Reconstruction of post-traumatic frontal-bone depression using hydroxyapatite cement. *Ann Plast Surg*. 2004;52:303–8; discussion 309.
10. Duman H, Deveci M, Uygur F, Sengezer M. Reconstruction of contour and anterior wall defects of frontal bone with a porous polyethylene implant. *J Craniomaxillofac Surg*. 1999;27:298–301.
11. Camarini ET, Tomeh JK, Dias RR, da Silva EJ. Reconstruction of frontal bone using specific implant polyether-ether-ketone. *J Craniofac Surg*. 2011;22:2205–7.
12. Altman K. Facial feminization surgery: current state of the art. *Int J Oral Maxillofac Surg*. 2012;41:885–94.

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IS NON-TRAUMATIC NAIL DYSTRPOPHY ONLY DUE TO CHRONIC ONYCHOMYCOSIS? THE ONYCHOMATRICOMA. CASE REPORT

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ACTA CHIRURGIAE PLASTICAE, 58, 1, pp. 43-45

SUMMARY

Onychomatricoma is a rare benign fibro-epithelial tumour that originates from the nail matrix and can affect the nail bed of fingers and toes. Onychomatricoma may represent a premalignant lesion and although the etiology is still not fully understood, a previous finger trauma is considered the main predisposing factor. Unlike previous scientific articles we report a case of a "non traumatic" onychomatricoma in a 60 years old woman underlining the clinical and histological features to distinguish this uncommon lesion from other lesions originating from the nail apparatus.

KEYWORDS

Onychomatrixoma, onychomatricoma, filamentous tufted tumour, onychomycosis

INTRODUCTION

Among the causes of chronic non-traumatic nail dystrophy, an infection by a dermatophytic fungus is by far the most common. In common practice the treatment of nail dystrophy and chronic onychomycosis is undertaken by general practitioners or dermatologists. Onychomatricoma (OM) is a rare benign nail tumour of fibro-epithelial origin, described originally by Baran and Kint in 1992 as Onychomatrixoma.[1]

In 1995, Hanekee and Fränken, based on histological aspects, proposed the term onychomatricoma, which has been most frequently used in the scientific literature since then.[2] Other quotes and nomenclature such as onychoblastoma, onychoblastic fibroma and atypical onychoblastic fibroma are currently found and based on histological basis.[3,4] It is considered a rare, premalignant lesion, also defined as a *"post-traumatic"* neoplasm.[1]

It is a specific tumour of the nail apparatus, characterized by the presentation of fingerlike projections from the matrix, and it is the only tumour in which alterations of the nail plate are actively produced by the lesion.[1,2] Its slow growth and the absence of pain in most cases explain patient's typical delay in seeking medical attention.

Since its first description, just over 40 cases have been reported. The majority of the scientific literature is focused on etiology, histological and clinical aspects, however the description of any surgical therapy is still missing. In this article we describe a case of a non-traumatic onychomatricoma, providing practical tools for a differential diagnosis from other more common conditions and giving technical tips for surgical reconstruction.

CASE REPORT

A 60 years old female was referred to our Unit with a painless nail dystrophy of the left middle finger with no previous trauma reported. Physical examination revealed a yellowish discoloration of the entire sterile matrix, associated with an abnormal thickness and dystrophic appearance (Fig.1). The skin of the perionychium appeared normal. No apparent mass was either palpable or painful on palpation. Neither sensory changes nor cold intolerance were detectable in the fingertip on the volar side. Previous unnecessary 2-month therapy with anti-fungal medicinal products (Itroconazole 400 mg daily) was ineffective. All previous fungal cultures were negative.

A T1-weighted MRI evaluation (Fig. 2) revealed a mass originating from the germinal matrix that was 7 x 6 mm wide, with low signal capture and resembling normal epidermis. Due to the presence of a proximal inflow and distal venous drainage with perforations in the nail plate, an excisional biopsy was mandatory.

Under axillary block and with pneumatic tourniquet at 250 mmHg, the yellowed nail plate with a transverse overcurvature was removed with a freer elevator (Ulrich Medical AG, St.Gallen, Switzerland). With the help of 3.5x magnification loupes, a solid greyish lesion involving the sterile matrix was identified and removed, leaving a free

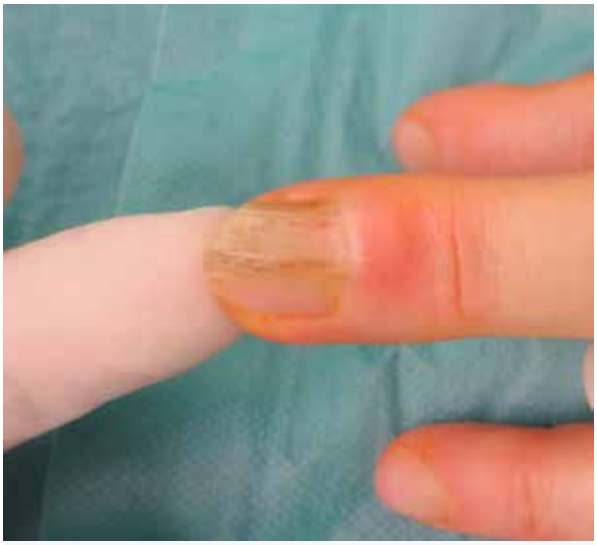

Fig. 1. Preoperative picture of the nail lesion. Note the typical appearance of the lesion with a yellowish discoloration of the entire sterile matrix, associated with an abnormal thickness and dystrophic appearance

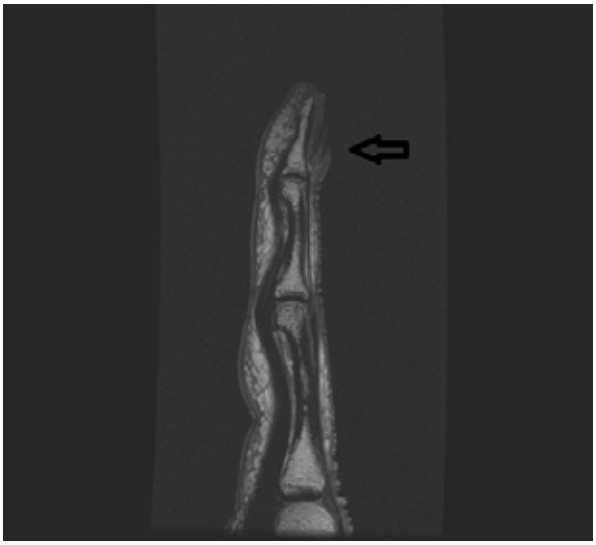

Fig. 2. A T1-weighted sagittal MRI showing a mass originating from the germinal matrix, 7 x 6 mm wide (black arrow). Note the low signal capture with an apparent cleavage plane either from the sterile matrix or the nail bed

margin of normal nail bed. The cleavage plane between the pathologic and normal nail bed was differentiated by the different colour and texture.

To prevent an early closure of the nail fold and keratinization of the nail bed, a polypropylene sheet was used as a sterile fingernail substitute. The sheet was trimmed from a reservoir of a common infusion set reproducing the profile of the avulsed fingernail and thinned at the proximal edge to reduce thickness in order to ease the insertion into the eponychial fold. A small hole was then created in the center of the foil to allow blood drainage and it was fixed with a 3-0 Prolene (Ethicon, Somerville, NJ) cross-stich suture (Fig. 3).

The substitute was removed after 6 weeks providing a good protection of the nail bed during the healing period. The histological examination revealed a fibroepithelial tumour with vertical filiform projections (Fig. 4) and confirmed the complete tumour excision. The aesthetic result after 9 months was excellent with no signs of local recurrence (Fig. 5).

Fig. 3. Immediate post-operative result. Note the sterile finger nail substitute to prevent an early closure of the nail fold and a keratinization of the nail bed

DISCUSSION

Onychomatricoma (OM) is a rare slow-growing benign fibro-epithelial tumour originating from the nail matrix, affecting the nail bed of fingers and toes, painless and associated with onychodystrophy. Baran and Kint described it originally in 1992 and clinical literature is still limited. OM affects mainly females (2.16:1) with a peak incidence around the age of 51,[5] rarely affects children and has prevalence in Caucasians although one case has been described in an African heritage.[6]

Etiology of nail dystrophy is not fully understood but trauma and onychomycosis are considered the main predisposing factors.

The OM is a slow growing painless tumour characterized by onychodystrophy, yellow longitudinal bands of variable width, distal splinter haemorrhages, prominent longitudinal ridging associated with woodworm-like cavities, increased transverse curvature of the nail plate, pincer nail deformity, cutaneous horn, melanonychia, nail bleeding and pterygium. [1] Radiographic imaging shows an involvement of the underlying bone and MR images include a Y-shaped appearance with holes transversally.

It can be differentiated from total dystrophic onychomycosis and the most common nail bed lesions mainly by the clinical appearance, radiological evaluation and the histological examination.[7,8] In onychomycosis the nail bed matrix and the entire thickness of the nail plate is involved. The nail plate invaded by the pathogenic fungus becomes so fragile that the nail simply breaks away. In glomus tumours the mass is *painful* and is usually associated with point tenderness, cold sensivity, nail ridging and purple or blue nail discoloration. MR features are intermediate-to-low signal on T1-weighted images, marked hyperintensity on T2-weighted images and strong enhancement after injection

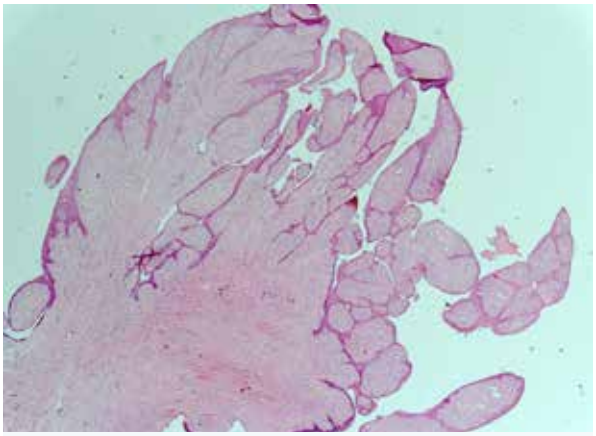

Fig. 4. Microscopic image of the fibroepithelial tumor. Note the abundance of digitate vertical filiform projections with a fibrous core and thin epithelial covering whereas the base of the tumor is composed of epithelium with V-shaped keratinous zones similar to those seen in the normal nail matrix (HE x 2.5)

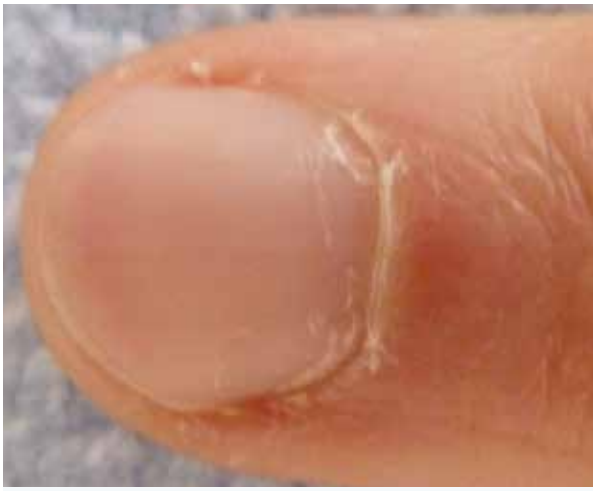

Fig. 5. Post-operative result after 9 months with no signs of local recurrencies

of gadolinium-based contrast material. On histopathology glomus tumour appears as endothelium-lined vascular spaces surrounded by round epithelioid cells that may take on a spindle form.[7] Subungual exostoses are painful, rapidly growing masses with associated cosmetic deformity. Radiograph studies are often diagnostic demonstrating a trabecular *bony* overgrowth projecting from the dorsal or dorsomedial distal phalanx.[7]

Another tumour that could simulate the picture of OM is the extraskeletal chondroma because it involves the subungual region. It is a painless subungual mass, a benign nodule of cartilage that does not connect to underlying bone causing mild and severe nail deformity.[7] On histopathology these lesions appear as well-circumscribed, lobulated masses of hyaline cartilage with variable cellularity and plump nuclei. Another lesion that should be differentiated from the OM is the fibro-osseous pseudotumour of the digit. It is a rare, ossifying lesion involving the subcutaneous tissues of digits presenting as painful, localized, polypoid, erythematous swellings that may be ulcerated and can affect the subungual region. Unlike all the aforementioned lesions, nail plate avulsion in onychomatricoma reveals typical finger-like projection originating from a villous tumour of the nail matrix.[2]

CONCLUSION

For the aforementioned reasons in spite of the rare occurrence of this benign neoplasm compared to other fungal infections we think that OM should be taken into consideration by hand surgeons dealing with *non-traumatic* nail dystrophies of uncertain origin to prevent recurrence and possible malignant evolution. Surgical excision with nail apparatus reconstruction provides a good aesthetic result.

Acknowledgements

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REFERENCES

1. Baran R, Kint A. Onychomatrixoma. Filamentous tufted tumour in the matrix of a funnel-shaped nail: a new entity (report of three cases). *Br J Dermatol*. 1992 May;126(5):510–5.
2. Haneke E, Fränken J. Onychomatricoma. *Dermatol Surg*. 1995 Nov;21(11):984–7.
3. Ko CJ, Shi L, Barr RJ, Mölne L, Ternesten-Bratel A, Headington JT. Unguioblastoma and unguioblastic fibroma--an expanded spectrum of onychomatricoma. *J Cutan Pathol*. 2004 Apr;31(4):307–11.
4. Cañueto J, Santos-Briz Á, García JL, Robledo C, Unamuno P. Onychomatricoma: genome-wide analyses of a rare nail matrix tumor. *J Am Acad Dermatol*. 2011 Mar;64(3):573–8.
5. Piraccini BM, Antonucci A, Rech G, Starace M, Misciali C, Tosti A. Onychomatricoma: first description in a child. *Pediatr Dermatol*. 2007 Jan-Feb;24(1):46–8.
6. Tosti A, Piraccini BM, Calderoni O, Fanti PA, Cameli N, Varotti E. Onychomatricoma: report of three cases, including the first recognized in a colored man. *Eur J Dermatol*. 2000 Dec;10(8):604–6.
7. Willard KJ, Cappel MA, Kozin SH, Abzug JM. Benign subungual tumors. *J Hand Surg Am*. 2012 Jun;37(6):1276–86.
8. Rashid RM, Swan J. Onychomatricoma: benign sporadic nail lesion or much more? *Dermatol Online J*. 2006 Oct 31;12(6):4.

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SALUTATIO ET LAUDATIO AD ANNIVERSARIUM PROFESSORIS WILLIAM GUNN

In February of this year Professor William Gunn of Geneva, Switzerland, celebrated a most remarkable 90th birthday jubilee. He is a highly respected Canadian surgeon who enjoys excellent mental and physical condition, and continues to perform the scientific and organizational work for which he has long been recognized throughout the world. As a pioneer of medical emergency systems, Professor Gunn has contributed greatly to the emergence and evolution of Disaster Medicine, Humanitarian Medicine, and the expansion of surgical fields in developing and "third world" countries. He worked closely with officials from many countries and has continued this collaboration with Czech healthcare and medical educational institutions; most notably with Charles University in Prague and the Czech Medical Association of J. E. Purkyně.

William Gunn was born on February 10, 1926, in British Cyprus, where his father was serving as Chief Medical Officer of His Majesty's Military Hospital. William Gunn completed his medical studies in Geneva; his doctoral thesis dealt with the haemostatic effects of thrombin in brain surgery, initial experiments which eventually led to the development of the fibrin sealants that are commonly used in surgery today. However, since 1967, the majority of his professional career has been devoted to the World Health Organization (WHO), for which he has performed such roles as: Director of Emergency Humanitarian Operations; Cabinet Head for the Presidents of the World Health Assembly; Consultant for the Effects of Nuclear War on Health and Health Services; WHO Adviser to the United Nations, UNESCO, UNICEF, and the European Union; Founding President of the WHO Medical Society; liaison for numerous universities; and a host of other esteemed positions.

Professor Gunn's laudable tenure with WHO has resulted in pioneering advancements in various fields, including a modern approach to eliminating or minimizing the public health impact of mass disasters and catastrophes; his educational programs have dramatically improved physicians' and other health care professionals' preparedness to provide medical assistance in extraordinary emergency conditions. Moreover, he created and persistently strove for the production of the WHO Emergency Health Kit to allow rapid response rescue work in mass casualty events. The contents of these kits are sufficient to provide 3 months of basic health care for 10,000 people, and they are stored in convenient locations throughout the world to ensure rapid dispatch to a given disaster site.

Professor Gunn has always applied his creative ingenuity in a most efficacious manner, implementing it with practical applications that continue to benefit globally operating organizations. In addition to founding both the European Centre for Disaster Medicine and the WHO Medical Society, he also co-founded the World Association

for Disaster and Emergency Medicine (WADEM), the Asia-Pacific Conferences on Disaster Medicine in Tokyo (APCDM), the Euro-Mediterranean Council for Burns and Fire Disasters (MBC), and has served as President of the International Federation of Surgical Colleges (IFSC). In 1984, he established and remains President of the International Association for Humanitarian Medicine (IAHM), which bears the name of Dr. Brock Chisholm, the first Director-General of WHO. The predominant operating principle of this organization and, in fact, William Gunn's entire life's work, is the premise that health is a basic human right and serves as a bridge to peace.

Professor Gunn has authored or co-authored more than 300 professional publications and 20 monographs, among which, titles such as *Humanitarian Medicine* (2005), *Understanding the Global Dimensions of Health* (2005), and *Concepts and Practice of Humanitarian Medicine* (2008). Both editions of his *Dictionary of Disaster Medicine and Humanitarian Relief* (1990, 2013) are very well known and widely used in practice throughout the world, and have been translated into several languages, including Japanese and Chinese. Professor Gunn founded several highly reputable professional journals, for which he served as Senior Editor for many years, e.g. *Prehospital and Disaster Medicine* (WADEM), *Annals of Burns and Fire Disasters* (MBC), *Disaster and Military Medicine*, and the *Journal of Humanitarian Medicine* (IAHM). He has also been a member of numerous other editorial boards, including *Acta Chirurgiae Plasticae* and presently serves as both an expert and consultant.

Due to his many years of interdisciplinary collaboration, Professor Gunn is very highly regarded in numerous national professional circles. His proactive advisory assistance provided the Czech Republic with significant incentive to construct a modern emergency medical services system after 1992, and to prepare and draft the healthcare sections of Acts No. 239/2000 Coll. (Integrated Rescue System) and No. 240/2000 Coll. (Crisis Management). His long-time collaboration with Burns Medicine practitioners at the Charles University 3rd Medical Faculty was fundamentally beneficial to the development of burn centers in Prague, Ostrava, Brno and Hradec Králové.

Professor Gunn's career of preeminent, meritorious service and his exceptional personal character have resulted in a long series of awards and formal recognition. Among these, it is worth noting that William Gunn is a Professor affiliated with 3 universities, and the recipient of the Cross and Ribbon of the Order of St. Agatha of San Marino, as well as awards from the Royal Society of Medicine and UN Economic and Social Council of Europe, for his many contributions to humanitarian medicine. For introducing essential surgery in the primary healthcare systems of developing countries he was also awarded the first Special Fellowship of the Royal College of Surgeons in Ireland. Professor Gunn holds honorary doctorates from several universities, learned societies, and medical associations; among which he was especially delighted to receive a doctorate honoris causa from Charles University in Prague (2004), and the Commemorative Medal of the Czech Medical Association of J. E. Purkyně (2006). Professor Gunn is a honorary member of numerous professional societies around the world. Some examples here in our own country include the Czech Burns Society, the Czech Society of Military Physicians, Pharmacists and Veterinarians and the Czech Medical Association of J. E. Purkyně. In 2014, he received the renowned international A. Meneghetti Prize for his life-long contributions to science and humanism.

In addition to his commendable scientific work in the aforementioned fields, Professor Gunn possesses a true Renaissance Personality that is reflected in his love of history, culture, and the arts. He particularly enjoys the topics of medical theory and disease management from the time of medicine's earliest beginnings; so much so, in fact, that he was Lecturer in History of Medicine at the University of British Columbia Medical Faculty, Canada. Professor Gunn has also studied the life, art, and culture of the indigenous peoples of Canada's Northwest Coast to great depths. In return, he was awarded the respected title of Honorary Medicine Man, was inducted as Chief in 3 Tribes, and was given the totemic name of Kwekwala-gila (Savior of Spirits). His promotion of the art of Canada´s First Nations from mere tribal artifacts to internationally recognized art was also a significant achievement. Furthermore, Gunn´s publication *Totem Poles of British Columbia* has become a classic in the field of anthropology, which led to his acceptance as a member of the Royal Anthropological Institute. Professor

Gunn is also an enthusiastic collector of classic literature, antiquarian books, and has compiled a valuable collection of historical maps. His appreciation for music is equally great, and he is especially fond of opera. It should be noted that, even when visiting Prague only briefly, he always strives to find time to attend our operas.

Professor William Gunn is an extraordinary personality whose tremendous work and contributions have benefitted the lives of thousands of vulnerable people around the world. An inspiration to his colleagues and successors; respecting and respected by all communities regardless of race, nationality, religion, culture or socioeconomic status; Professor Gunn is the quintessential international envoy of medicine and true humanism. We wish him excellent health in the coming years; continued unwavering enthusiasm and energy in his pursuits; and many precious moments with his beloved wife Jean, 2 daughters, grandchildren, and countless friends around the world.

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Inhzerce

ČESKÉ SOUHRNY

ACTA CHIRURGIAE PLASTICAE, 58, 1, pp. 49-50

ZHODNOCENÍ KOMPLIKACÍ PO ENDOSKOPICKY ASISTOVANÉ OTEVŘENÉ REPOZICI A INTERNÍ FIXACI JEDNOSTRANNÉ ZLOMENINY KLOUBNÍHO VÝBĚŽKU DOLNÍ ČELISTI. RETROSPEKTIVNÍ ANALÝZA 2010–2015

Machoň V., Klíma K., Vlachopulos V., Valach J., Levorová J., Foltán R.

Východiska. Autoři prezentují zkušenost s endoskopicky asistovanou otevřenou repozicí a interní fixací zlomenin kloubního výběžku dolní čelisti. Své výsledky demonstrují v retrospektivní studii 33 pacientů s jednostrannou subkondylární zlomeninou, kteří podstoupili v letech 2010–2015 tento operační výkon. Hodnocena byla dosažená repozice a fixace, stabilita okluze 12 měsíců po operaci a dále přítomnost komplikací.

Výsledky. Vyhovující repozice (anatomické či fyziologické) bylo dosaženo u 31 pacientů. Stabilita okluze byla zhoršena u jednoho pacienta (následkem kondylární resorpce). Z komplikací dominovaly zánětlivé komplikace (4 pacienti) a přechodná paréza lícního nervu (3 pacienti). Poruchy funkce čelistního kloubu nebyly zaznamenány u žádného pacienta.

Závěr. Endoskopicky asistovaná otevřená repozice a interní fixace je alternativou klasických chirurgických přístupů, vyžaduje však specializované instrumentarium a zkušený operační tým.

NUMERICKÉ HODNOCENÍ JIZVY PO REKONSTRUKCI PRSTU BŘIŠNÍM POSUVNÝM LALOKEM

Kovář M., Čapek L., Vítová L., Molitor M.

Východiska. Léčba karcinomu prsu se v posledním desetiletí významně rozvíjela, nicméně stále zůstává významným sociálním i ekonomickým problémem na celém světě. Volba chirurgického výkonu závisí jednak na léčebném protokolu, jednak na preferenci lékaře. Cílem této studie je zhodnotit namáhání jizvy po rekonstrukci prsu.

Metoda. Matematický model ke studování namáhání sešitého kožního laloku použitého při rekonstrukci prsu byl rozdělen na dvě části. V první části byl matematickým modelem zkoumán silikonový implantát. Následně bylo provedeno matematické modelování prsu s implantátem.

Výsledky. Maximální geometrický rozdíl u anatomického i kulatého implantátu je umístěn na dolní a horní ploše prsu, zatímco oblast laterální a kolem areoly dosahuje vysoké shody. Největší tenze je lokalizována v místě dvou středových stehů. Maximální síla dosahuje 0,025 N. Cauchy stress equivalent je umístěn kolem bradavky a dosahuje hodnoty 380 kPa.

Závěr. Naše výsledky ukazují, že anatomický a kulatý implantát nepřináší stejné zatěžování jizvy. Maximální rozdíl dosahuje 13,4 %, s tím, že kulatý implantát zatěžuje tahem jizvu výrazněji než implantát anatomický.

TRANSPLANTACE VASKULARIZOVANÝCH KOMPOZITNÍCH ALLOGRAFTŮ. STRUČNÝ PŘEHLED SOUČASNÝCH POZNATKŮ

Molitor M.

Transplantace v rekonstrukční chirurgii se provádějí již více než 20 let, i když oficiálně se za začátek éry těchto výkonů považuje první úspěšná transplantace ruky v roce 1998. Původní název „Composite Tissue Transplantation" se nyní používá méně, více se užívá termín „Vascularized Composite Allotransplant", který lépe vystihuje podstatu výkonu. Celkově bylo doposud provedeno přibližně 180 těchto transplantací, přesný počet se dohledává jen velmi obtížně. Nejznámějšími transplantacemi z této skupiny jsou transplantace ruky a obličeje, ostatní jako transplantace břišní stěny, kloubů, kostí, trachey, laryngu, jazyka, penisu, dělohy apod. jsou méně časté a méně známé. Jejich společným rysem je to, že neslouží k záchraně či prodloužení života, ale ke zlepšení jeho kvality. Kvalita života je hodnota, která se nedá objektivně měřit a názory na její důležitost se významně liší. Proto je pro tyto výkony charakteristické stále nevyřešené etické dilema, jehož podstata spočívá v obhajitelnosti užívání imunosupresivní terapie s jejími závažnými riziky v případech, kdy výkon není nezbytně nutný k záchraně či zachování života.

ALOTRANPSLANTACE TRACHEY A REGENERACE

Delaere P., Molitor, M.

Benigní a maligní obstrukce průdušnice způsobují signifikantní morbiditu a mortalitu. Při dlouhotrvajícím používání arteficiálních náhrad vzduchových cest stoupá riziko benigních a iatrogenních komplikací. Stenóza trachey kratší pěti centimetrů může být resekována s provedením anastomózy end-to-end. Delší tracheální defekty mohou být paliativně léčeny implantací stentu k zachování průchodnosti vzduchových cest. Řešení defektů trachey je progresivně se rozvíjející oblastí. Transplantace trachey a tracheální regenerace může přinést velké léčebné výhody u případů s rozsáhlým tracheálním postižením. Publikovaný přehled popisuje současné možnosti a budoucí vize v oblasti transplantace a regenerace trachey.

PLICNÍ EMBOLIE PO ABDOMINOPLASTICE – JSME SKUTEČNĚ SCHOPNI VYHNOUT SE VŠEM KOMPLIKACÍM? KAZUISTIKY A PŘEHLED LITERATURY

Molitor M., Měšťák O., Popelka P., Vítová L., Hromádková V., Měšťák J.

Plicní embolie je u pacientů plastické chirurgie potenciálně letální komplikací. Přibližně 34 % členů Americké společnosti plastické chirurgie ve své praxi diagnostikovalo plicní

embolii u svých pacientů, a 7 % z nich mělo pacienta, který na uvedenou komplikaci zemřel. Výkonná rada Americké společnosti plastické chirurgie proto ustanovila speciální komisi zabývající se venózní trombembolií. Členové této komise se shodují na tom, že není dostatečné množství relevantních údajů, aby bylo možno vyslovit komplexní doporučení pro profylaxi trombembolické nemoci a plicní embolie u pacientů plastické chirurgie. Nicméně pro použití schválila Caprini Scale z roku 2005 doplněnou o své doporučení. Je všeobecně velmi vhodné aplikovat adekvátní profylaktická opatření proti venózní trombembolii u všech chirurgických procedur. Nicméně ani pak se nemůžeme zcela vyhnout této vážné komplikaci.

POUŽITÍ OSTEOTOMIE U POTRAUMATICKÉ DEFORMITY PŘEDNÍ STĚNY FRONTÁLNÍHO SINU. KAZUISTIKA

Němec I.

Poúrazovou deformaci přední stěny frontální sinu můžeme řešit různými způsoby. Běžnou metodou je využití některého typu implantátu. V našem případě jsme provedli osteotomii a následnou repozici fragmentů do anatomického postavení. K fixaci jsme použili titanové minidlahy a šrouby. Uvedená kazuistika ukazuje na možné využití této metody u pacientů s rozsáhlejší čelní dutinou a výraznou poúrazovou deformací. V literatuře jsme nenalezli obdobný případ řešený popsaným způsobem.

JE NETRAUMATICKÁ DYSTROFIE NEHTU POUZE DŮSLEDEK CHRONICKÉ ONYCHOMYKÓZY? ONYCHOMATRIKOM. KAZUISTIKA

Lucchina S., Maggiulli F.

Onychomatrikom je vzácný benigní fibroepiteliální tumor, který vychází z nehtové matrix a může postihovat nehtové lůžko prstů na nohou a rukou. Onychomatrikom může představovat premalignì lézi a i když je jeho etiologie stále ne dobře pochopena, je předchozí poranění prstu považováno za hlavní predisponující faktor. Na rozdíl od předchozích vědeckých článků prezentujeme kazuistiku „netraumatického“ onychomatrikomu u 60leté ženy a ukazujeme klinické a histologické charakteristiky pro odlišení této méně časté léze od jiných lézí vycházejících z nehtového aparátu.

inzerce

INSTRUCTIONS TO THE AUTHORS

ACTA CHIRURGIAE PLASTICAE, 58, 1, pp. 52-55

The journal *Acta Chirurgiae Plasticae* is an international journal of plastic surgery. It is published in English with Czech/Slovak structured abstracts four times a year. There are articles dealing with problems of plastic, reconstructive and aesthetic surgery, craniofacial surgery, hand surgery, microsurgery, burns and allied and cooperating fields of medicine. The journal accepts the following types of articles for publication: original scientific papers including experimental studies, case reports, review articles, discussions, reviews of domestic and foreign publications, news (invitations to specialized meetings, reports from congresses and meetings, letters to the editors, etc.) and other important information from the specialty. All articles are subject to a peer review procedure, whereas bilateral anonymity is maintained. The editorial board accepts articles in English, or possibly after a previous agreement also in Czech and Slovak languages. Only articles that have not been previously published elsewhere can be accepted.

REQUIREMENTS FOR FORMAL STRUCTURE OF THE MANUSCRIPT

The whole manuscript including the attachments must be made available in electronic form. The article should be written in one of commonly used text editors (best is MS Word), recommended font size is 12, Times New Roman, spacing 1.5, width of text 15 cm, no underlying, with switched off automatic functions. The text file must be named so that it could not be mistaken (name of the file without diacritic marks, e.g. surname of main author, key word of the paper and the word text, for example: "Smith_reconstruction_text.docx"). Recommended extent is maximally 10 normalized pages (counted without title page, abstract and literature, 1 normalized page = 1800 characters without spaces). Each section should be started on a new page. In the manuscript text, please observe the following order: title page, summary, key words, actual text of the paper and summary of used literature.

Tables, charts and images to the articles should be marked in the actual text (for better orientation) and attached in a separate file. Tables and charts must be sent in a form of individual files (or individual excel sheets), which can be edited (best is MS Excel, MS Word). Tables and charts should be prepared appropriately simple and comprehensive, numbered according to the order of occurrence within the text. There should be a brief description to each table and chart. You should also explain all abbreviations, which were used. You should also verify, whether all tables and texts are really referenced in the text. Name the file should be made the same way as in the text (e.g. "*Smith_reconstruction_text.xlsx*"). Imaging documents should be sent in an electronic form as JPG, BMP, TIFF with resolution at least 300 dpi. If the image is printed in the size of one third of a page, it must have a minimal width of 700 pixels, in the size of two thirds of a page it must have a minimal width of 1500 pixels and in the size of the whole page it must have a minimal width of 2200 pixels. If there is imaging documentation reprinted from another source, it is necessary to provide the original source and a written consent of the copyright holder. Imaging documents cannot be received in MS PowerPoint form. Imaging attachments are numbered according to the occurrence in the text and stored individually as separated files, named analogically as the other files (e.g. „*Smith_reconstruction_pict1.jpg*"). The legend to the imaging documentation should be submitted as a separate file in MS Word named analogically as the other files (e.g. „*Smith_reconstruction_legends.docx*") and possible symbols and abbreviations should be explained.

TITLE PAGE

Title page must contain brief and clear name of the article (maximum 10 words), in the case reports this should be included in the name.

It must also contain full name and surname of all authors, in the order reflecting their participation on the manuscript, name of workplaces of all authors (in case of more workplaces, name the first where the manuscript was created mostly), address of the main author, telephone and email address, where should be sent the correspondence related to the manuscript.

In case there was financial support or non-financial support used during the preparation of the article (grants, equipment, medication, etc.), it is necessary to provide in sufficient extent the source of this support. Possible acknowledgement may be located before the literature section.

STRUCTURE OF ORIGINAL PAPER

In the original paper the author works with his/her own file and provides his/her own ideas related to the particular problem based on the analysis of his/her own results and using appropriate statistical methods. The text must be written at appropriate scientific level and comprehensively. The conclusions must be formed clearly and so that any different interpretation was ruled out. The text of the original article must follow a prescribed structure.

Abstract – structured abstract represents summary of article content into a brief form. Characteristic information is required from the article. Structure of the abstract of the original paper copies the structure of the whole paper, i.e. it contains the following chapters "Introduction, Material and methods, Results, Discussion and Conclusion". The abstract should have an extent of a maximum of one normalized page (maximum of 1800 characters).

Key words – 3-8 words or short phrases that enable characterizing the paper with regards to its content. It is recommended to use terms that originate from the recommended terms of the National Library of Medicine: Medical Subject Headings (MeSH).

Introduction – brief and clear description of the problem including reference to the basic literature and formulation of the goal of the patient or working hypothesis, brief introduction about the origin of the article.

Material and methods – a basic description of the file, summary of used methods, description of the hypothesis and methods within the study, including the method of evaluation and used statistical method.

Results – obtained data and their evaluation.

Discussion – brief confrontation with similar studies and papers from the last two or more years. Evaluation of achieved study goals.

Conclusion – brief and clear summary with clearly formulated outputs for practice.

Literature – citation according to the instructions for authors, organized according to the occurrence in the text, only relevant citations.

STRUCTURE OF REVIEW ARTICLE

Review article should summarize the current knowledge about aetiology, pathogenesis, diagnostics and therapy of a disease or group of diseases, or complex review of the issues related with the topic of the journal. After reading the article the reader should obtain a sufficient and current idea about the particular topic. The article should be written with a maximum emphasis on its practical use. Instructive imaging documentation is welcome.

The contribution of the author to the particular problem should be based on extensive study of literature, provided in the list of used literature but also on the own work of the author. In case of processing a more extensive topic, it is possible to divide the article into several parts after an agreement with the editorial board.

Summary – brief summary of the content of the article in the extent of a maximum of 1000 characters.

Key words – 3-8 words or short phrases enabling documentation of the content of the paper with regards to its content; it is recommended to use the terms from the recommended terms of the National Library of Medicine: Medical Subject Headings (MeSH).

Introduction – brief explanation of the origin of the article, proposal of the theme and its limitations.

Evaluation of the topic – brief basic thoughts of the paper, own approach of the author, review of current knowledge.

Conclusion – brief message of the paper.

Literature – citation according to the instructions for the authors, organized according to the occurrence in the text.

STRUCTURE OF CASE REPORT

Case report is a description of one or several similar cases and their solution. The case reports should be in some extent unique and their solution should be innovative, or possibly it should supplement or confirm current knowledge.

Summary – brief summary of the content of the article in the extent of a maximum of 200 characters.

Key words – 3-8 words or short phrases enabling documentation of the content of the paper with regards to its content; it is recommended to use the terms from the recommended terms of the National Library of Medicine: Medical Subject Headings (MeSH).

Introduction – brief explanation of the origin of the article, description of the topics.

Description of the case – there are all important data related to the described case including history, clinical picture, possibly results of laboratory examination, description of the finding of imaging techniques, therapeutic procedure and result.

Discussion – it should be brief and it discusses the actual case report with regards to similar case reports or papers of other authors, which are cited.

Conclusion – brief summary of the most important aspects of the paper.

Literature – citation according to the instructions for the authors, organized according to the occurrence in the text. Only relevant citations.

Use metric units and SI units. Use only established abbreviations, do not use any abbreviations in the header and summary, in case of the first use of the abbreviation in the text, provide expanded version in brackets. List of abbreviations in alphabet order with explanation may be provided before the list of used literature. In case of medication it is necessary to provide a generic name and producer in the product name.

LITERATURE

The manuscript may contain only the actual sources, i.e. publication referenced by the authors in the text or papers that are really important (no papers may be provided only from formal reasons). Literature may be arranged according to the occurrence in the text, not in alphabet order, it is marked with a number of appropriate reference number written as upper index and it is cited according to Uniform Requirements for Manuscripts Submitted to Biomedical Journals" according to "Vancouver citation format".

In case of references to the papers that were not published yet, however already accepted for publication, please provide the name of the journal with the note "in print". References within the text, tables or descriptions of images should be marked with Arabic numbers in hard brackets. Several sources should separated by a comma, without spaces.

EXAMPLES OF CORRECT FORMS OF CITATIONS:

Article in a journal:

Provide full surname of the authors, initials of the name without a full stop, put comma between the authors, after the last name is a full stop. If the number of authors is more than 6, put first three authors and an abbreviation "et al.". Name of the article should be terminated with a full stop. Then is written the official abbreviation of the article (name of the journals is abbreviated according to a style used in Index Medicus) and year (possibly even month) of issue, do not separate with a comma, after the year put a semicolon. Year of the journal and possibly number of issue in parenthesis, colon, pages completed with a full stop.

Examples:

Petitti DB, Crooks VC, Buckwalter JG, Chiu V. Blood pressure levels before dementia. *Arch Neurol.* 2005 Jan;62(1):112-6.

Chapter in a book:

In the authors write their full surname, initials of the name without a full stop, between the authors put comma, after the last name put full stop. The name of the book is separated with a comma, number of issue is terminated with a full stop. City of issue and in round bracket country of issue and colon, publisher, semi-colon, year of issue, full stop, name of chapter, semi-colon and pages terminated with a full stop.

Examples:

Riffenburgh RH. *Statistics in medicine*. 2nd ed. Amsterdam (Netherlands): Elsevier Academic Press; c2006. Chapter 24, Regression and correlation methods; p. 447-86.

Book, monograph:

In the authors put full surname, initials of the name without a full stop, between authors put comma, after the last name put full stop. Name of the book is terminated with a full stop and number of issue is terminated with a full stop. City, colon, publisher, semi-colon, year of issue, full stop and total number of pages terminated with a full stop.

Examples:

Eyre HJ, Lange DP, Morris LB. *Informed decisions: the complete book of cancer diagnosis, treatment, and recovery*. 2nd ed. Atlanta: American Cancer Society; c2002. 768 p.

EXAMPLES OF OTHER CITATIONS:

Article in electronic serial publication:

Polgreen PM, Diekema DJ, Vandeberg J, Wiblin RT, Chen YY, David S, Rasmus D, Gerdts N, Ross A, Katz L, Herwaldt LA. Risk factors for groin wound infection after femoral artery catheterization: a case-control study. Infect Control Hosp Epidemiol [Internet]. 2006 Jan [cited 2007 Jan 5];27(1):34-7. Available from: http://www.journals.uchicago.edu/ICHE/journal/issues/v27n1/2004069/2004069.web.pdf

Electronic publication:

Richardson ML. Approaches to differential diagnosis in musculoskeletal imaging [Internet]. Version 2.0. Seattle (WA): University of Washington School of Medicine; c2000 [revised 2001 Oct 1; cited 2006 Nov 1]. Available from: http://www.rad.washington.edu/mskbook/index.html

Article from web pages:

Complementary/Integrative Medicine [Internet]. Houston: University of Texas, M. D. Anderson Cancer Center; c2007 [cited 2007 Feb 21]. Available from: http://www.mdanderson.org/departments/CIMER/.

Article from online database:

MeSH Browser (2011 MeSH) [Internet]. Bethesda (MD): National Library of Medicine (US), Medical Subject Headings Section; [1999] – [updated 2010 Aug 28; cited 2011 Jul 8]. Available from: http://www.nlm.nih.gov/mesh/MBrowser.html Files are updated every week on Sunday.

Complete instructions for citation and rules for citations other than above examples of the sources according to "Vancouver citation format" is available at:

http://www.ncbi.nlm.nih.gov/books/NBK7256/

ETHICAL ASPECTS

The condition to publish clinical research is that the used procedures corresponded to the ethical principles of Helsinki declaration from 1975 (revised in 2000) and they were approved by appropriate ethics committee. In case of animal studies, it is necessary to document that valid regulations and directives for breeding and experimental use of animals were observed. The authors must declare compliance with such conditions in written in a cover letter. All information about patients must respect the rules set forth by relevant law on protection of personal data. No names of patients, their initials or hospital (treatment, reference) numbers are provided, especially in any imaging material. The clinical photographs of the patients must be adjusted so that the patient could not be identified. If such adjustments are not possible with regards to the nature of the paper, it is possible to provide written informed consent of the patient (possibly family or guardian) with publishing such photographs.

STATISTICS

Used statistical methods should be sufficiently described so that the reader with access to the original data could verify the results. The editors recommend that the author before completing the paper discusses all used statistical methods with a professional statistician who deals with biomedicine.

AUTHORSHIP AND COPYRIGHTS

Only a manuscript that was not published in another journal, not even partially, will be accepted for publication. The cover letter must contain a statement that the article or its part was not sent to another journal. As co-authors may be mentioned only those who significantly contributed to the preparation or overall performance of the study, to analysis and interpretation of the findings or to processing, editing and adjustment of the text. All co-authors must consent with the final version of the manuscript. The order of authors must correspond to their effort during the performance of the study and writing of the manuscript. Published articles are property of the journal – copy of the articles or of their part may be published only with the consent of the editorial board with provision of the source.

REVIEW OF THE ARTICLE

Review of the article is bilaterally anonymous. The editors perform anonymization of the text, i.e. removal of data that could help identify the authors before the text proceeds to the review process. Each text submitted for publication in the journal *Acta chirurgiae plasticae* is (apart from reviews, reports, medallions and some other information) provided to two peers for review. The chief editor chooses specialists for the review in the field, which corresponds to the content of the text. He/she also considers that the reviewers were not closely related to the author, by common institution or personally. Reviewers fill out a standardized form whether the they recommend the text for acceptance, rewriting or refusal. Their decision is explained in the opinion into which they can also include recommendation for adjustment of the text. The editors have a right to propose the author shortening of the manuscript, adjustments (language of the manuscript), and possibly after the review they can return the manuscript to the author to rewrite. Confirmation that the article was accepted for printing in the journal *Acta chirurgiae plasticae* is provided to the author only after both reviewers accepted the article for publishing. Proofreading must be

send to the editors within three days; the text is confirmed for publication only by the chief editor.

PAYMENTS

Manuscripts of articles, information and reports sent for publication to the journal *Acta Chirurgiae Plasticae* are not subject to a payment of the authors. They are published on the expense of the publisher.

Advertisements and other commercial information from companies are subject to payment according to the valid pricelist of the publisher.

CONFLICT OF INTEREST

Authors are obliged to send a statement together with the manuscript that in relation with the theme, creating and publication of this manuscript they are not in conflict of interest. It means that the creation of the manuscript and its publication was not financially supported by any pharmaceutical or other company or other subject and none of the authors was influenced during the creation of the paper in any way.

Otherwise the main authors is obliged to report whether and how was the main author or any of the co-authors in relation to the writing and to the theme of the manuscript within the last 24 months contractually bound, whether and from what subject was obtained any financial support for the work and publication, whether and who supported his/her/their participation in a specialized meeting or conference related to the theme of the manuscript, etc.

SENDING THE MANUSCRIPTS

The manuscript and the cover letter corresponding to the aforementioned requirement may be sent in a written printed form and also in an electronic form on CD, DVD or flash disc to the following address: **MUDr. Aleš Fibír, Oddělení plastické chirurgie a léčby popálenin, Fakultní nemocnice Hradec Králové, Sokolská 581, Hradec Králové, PSČ 500 05, Czech Republic**. If the electronic form of the manuscript is smaller than 8 Mb, it is possible to send it as an attachment to an email to the following address: fibir@seznam.cz. When sending larger files, it is possible, after a previous agreement, to use also commercial provider for delivering of data.

COVER LETTER

The manuscript must be accompanied with a cover letter that contains the following information: name of the paper, format of the paper, name and surname of the authors, statement of the authors regarding approval of the ethics committee (experimental or clinical studies) or in case of an animal study a statement of compliance with the procedures during manipulation with experimental animals, statement about possible conflict of interests, statement that all materials (schemas, images, charts, tables, etc.) obtained from other sources or publications were used with the consent of the person or publisher, which have appropriate copyright or publishing rights to that reproduced material, furthermore statement that the manuscript is approved for publication by all authors, name and address of the main author, his/her telephone and email address where all correspondence related to proofreading and publication should be sent. The cover letter must be signed by all authors.

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