ACTA CHIRURGIAE PLASTICAE

INTERNATIONAL JOURNAL OF PLASTIC SURGERY, MAXILLOFACIAL SURGERY, HAND SURGERY AND BURNS

Vol. 42 • 1/2000

PUBLISHED BY THE CZECH MEDICAL ASSOCIATION J. E. PURKYNĚ

ISSN 0001-5423

INDEXED IN EMBASE/Excerpta Medica, MEDLINE/Index Medicus, BIOLOGICAL ABSTRACTS

Ialugen® PLUS

Natrii hyaluronas + Sulfadiazinum argenteum

Krém

Balení: 20 g

Částečně hrazeno zdravotními pojišťovnami

Gázové polštářky s krémem

(10x10 cm)

Balení: 5 a 10 ks

PLNĚ HRAZENO ZDRAVOTNÍMI POJIŠŤOVNAMI

Přípravek je vhodný pro hojení infikovaných mechanických, termických a kaustických kožních traumat, torpidních dekubitů a bércových vředů.

IALUGEN® PLUS tvoří účinnou kombinaci při léčbě kožních lézí. Zatímco kyselina hyaluronová stimuluje hojení a reepitelizaci postižené tkáně, sulfadiazinum argenteum zabraňuje bakteriální kontaminaci a chrání před další infekcí.

IBSA

výrobce:
IBSA, Institut Biochimique SA
Lugano, Švýcarsko

Výhradní zastoupení a distribuce:

IBI spol. s r. o.

Sokolovská 24, 186 00 Praha 8
tel.: 02/232 50 26, 231 93 48, fax: 02/231 92 63

ACTA CHIRURGIAE PLASTICAE

No. 1, 2000

CONTENTS

SCOPE AND LIMITATIONS

Acta Chirurgiae Plasticae is an international journal with a long-standing tradition respected by the professional public worldwide. It is published in English four times per year. The journal contains clinical, experimental and theoretic studies from the discipline of plastic, reconstructive and aesthetic surgery, surgery of the hand, craniofacial surgery, treatment of burns and allied surgical disciplines (traumatology, orthopaedics, gynaecology etc.). In the journal you will also find reviews, case-histories, innovations, comments, reports from study trips and congresses, reviews of books and various announcements.

ACTA CHIRURGIAE PLASTICAE

SUBSCRIPTION AND FEES

Price for a single issue: Kč 71,- (Czech Republic), Sk 77,50 (Slovak Republic).
1999 subscription rate: Kč 284,-, Sk 310,-, respectively.
Information on subscription rate for other countries provides: CzMA JEP, Sokolská 31, 120 26 Prague 2, Czech Republic.
Subscription orders should be sent to the Publishing Division of the Czech Medical Association JEP, Sokolská 31, 120 26 Prague 2, Czech Republic, or by fax No.+4202/249 11 420 or by e-mail: nts@iol. cz.
http://www.clsjep.cz

I hereby subscribe to Acta Chirurgiae Plasticae

Name .... Date ....

Full address ....

....

.... Signature ....

ACTA CHIRURGIAE PLASTICAE

 Published four times a year by the Czech Medical Association J.E.Purkyně, Sokolská 31, 120 26 Prague 2, Czech Republic. Printed by MTT, Za Poříčskou bránou 9, Prague 8. Distribution for the Czech Republic and Slovak Republic: ADLEX System, Pravoúhlá 26, 150 00 Prague 5. Distribution abroad: ABONT s. r. o., Chlumova 17, 130 00 Prague 3. Price for a single issue: Kč 64,- (Czech Republic), Sk 73,- (Slovak Republic). 1999 subscription rate: Kč 256,-, Sk 292,-, respectively. Subscription orders should be sent to the Publishing Division of the Czech Medical Association JEP, Sokolská 31, 120 26 Prague 2, Czech Republic, or by fax No. +4202/249 11 420. Manuscripts should be sent to Acta Chirurgiae Plasticae, Šrobárova 50, 100 34 Prague 10, Czech Republic. Advertisement and inquiries concerning conditions of advertising should be sent to Advertisement Department of the Czech Medical Association JEP, Vršovická 17, 101 00 Prague 10, Czech Republic, e-mail: ntsinzerce@iol.cz. Podávání novinových zásilek povoleno Ředitelstvím pošt Praha, č.j. NP 1558/1994, ze dne 13.7.1994. Registrační značka MK ČR F 4844. Indexed in Excerpta Medica/EMBASE, Index Medicus/MEDLINE, Biological Abstracts. Internet service provider: EuroNet. Cz., spol. s r. o., Štěpánská 18, 110 00 Prague 1, phone number: +4202/22 23 07 02, fax: +4202/22 23 07 08; e-mail: medical@euronet.cz; Internet: www.Medical.cz.

ACTA CHIRURGIAE PLASTICAE 42, 1, 2000, pp. 3 - 6

EFFECTS OF A SILICONE-COATED POLYAMIDE NET DRESSING AND CALCIUM ALGINATE ON THE HEALING OF SPLIT SKIN GRAFT DONOR SITES: A PROSPECTIVE RANDOMISED TRIAL

O'Donoghue J. M., O'Sullivan S. T., O'Shaughnessy M., O'Connor T. P. F

Department of Plastic Surgery, Cork University Hospital, Wilton, Cork, Ireland

SUMMARY

An open randomised prospectively controlled trial was performed to assess the healing efficacy, slippage rate and degree of discomfort on removal of calcium alginate and a silicone-coated polyamide net dressing on split skin graft donor sites. Sixteen patients were randomised to the calcium alginate group and 14 to the silicone-coated group. The donor sites were assessed at days 7, 10, 14 and up to day 21. The mean time to healing in the calcium alginate group was 8.75 ± 0.78 days (range 7 to 14 days) compared to 12 ± 0.62 days (range 7 to 16 days) for the silicone-coated group ($p < 0.01$). Although more silicone-coated dressings slipped (5 versus 1), the difference was not statistically significant. Pain during the first dressing change was assessed using a visual analogue pain scale. Although no significant differences were found between the groups, it was necessary to change the dressing protocol in the silicone-coated arm of the trial after entering the first two patients. Overlaid absorbent gauze adhered to the donor site through the fenestrations in the dressing necessitating the placement of paraffin gauze between the experimental dressing and the overlying cotton gauze. There was one infection in the study, occuring in the alginate group. Based on these results we recommend calcium alginate as the dressing of choice for spilt skin graft donor sites.

ZUSAMMENFASSUNG

Die Auswirkung des mit Silikon bezogenen Polyamidnetzverbandes und Kalziumalginats auf die Heilung der gespalteten Hautspalte der Entnahmestelle: der prospektive randomisierte Versuch

O'Donoghue J. M., O'Sullivan S. T., O'Shaughnessy M., O'Connor T. P. F.

Es wurde durchgeführt der geöffnete randomisierte prospektiv gesteuerte Versuch, um die Auswirkung der Heilung, das Rutschungsmaß und das Unbeqeumlichkeitsgrad bei der Abnahme des Kalziumsalginates- und des mit Silikon bezogenen Polyamidnetzverbandes von der gespalteten Hautspalte der Entnahmestelle festzusetzen. Zufällig wurden eingereiht 16 Patienten in die Gruppe mit dem Kalziumalginatsverband und weiteren 14 in die Gruppe mit dem Silikon bezogenen Verband. Die Entnahmestellen werden ausgewertet vom 7, 10, 14 bis zum 21. Tag. Die durchschnittliche Heilungsdauer in der Gruppe mit Kalziumalginat war 8, 75 ± 0,78 Tage (im Zeitabschnitt von 7 bis 14 Tagen) im Vergleich zu 12 ± 0,62 Tage (im Zeitabschnitt von 7 bis 16 Tagen) der Silikongruppe ($p < 0{,}01$). Obwohl die mit Silikon bezogenen Verbände öfters herabrutschten (5:1), der Unterschied war statistisch von keiner Bedeutung. Der Schmerz während des ersten Verbandswechsels wurde anhand der visualen analogen Schmerzskala festgelegt. Obgleich keine signifikante Unterschiede zwischen den Gruppen gefunden wurden, war notwendig nach dem Beginn das Verbandsprotokoll bei mit dem Silikon bezogenen Armes der ersten zwei Patienten zu verändern. Das obere Absorbsgaze, die zur Entnahmestelle über die Fenestration im Verband anlag, verlangte die Anlegung des parafinierten Gazas zwischen den experimentalen Verband und das überliegende Baumwollegaza. In der Studie wurde eine Infektion festgestellt, die in der Alginatgruppe passierte. Aufgrund der Ergebnissen empfehlen wir das Kalziumalginat als mögliche Verbandswahl für die gespaltete Hautspalte der Entnahmestelle.

Key words: split skin graft, donor site, calcium alginate, silicone, dressings

Choosing the most appropriate wound dressing is of importance in optimizing healing and minimizing pain. In a previous randomised trial we demonstrated the healing efficacy of calcium alginate over paraffin gauze on split skin graft donor sites (O'Donoghue, 1997). The value of calcium alginate as a donor site dressing has also been confirmed in other studies (Atwood, 1989; Basse, 1992). Its mechanism of action appears to result from an ion exchange reaction between the calcium of the alginate filaments and the sodium present in blood and exudate on the wound surface.

A newer synthetic dressing has been developed and is marketed as non-adherent but permeable to excess exudate (Mepitel^R, Molnlycke).

This dressing is sterile and made of medical grade silicone gel bonded to a soft and pliable polyamide net. The net is flexible and easily cut, thereby enabling it to conform to almost any contour. The porous nature of the net prevents the collection of excess exudate beneath the dressing. Despite the fact that the dressing does not adhere to moist surfaces, the silicone gel does adhere to dry normal skin, thus theoretically preventing it from slipping. These potentially beneficial features of silicone net as a donor site dressing were examined in an open prospectively randomised controlled trial. Calcium alginate (Kaltostat[R], Britcair) was used as the comparative dressing.

MATERIALS AND METHODS

Following approval by the Clinical Research Ethics Committee of University College Cork, 30 patients were randomised into one of two treatment groups. Those included in the trial were fit, healthy adults who could give informed consent and who presented with small full thickness defects (< 10 x 18 cm) which required split skin graft cover (Table 1). Those excluded included children, patients on long term steroids, diabetics, patients with autoimmune collagen vascular diseases and patients with general debility including those with nutritional deficiencies.

Tab. 1. The defects requiring split skin graft cover

Defects	Calcium alginate	Silicone net
Burns	3	5
Pretibial lacerations	5	4
Degloving injuries	7	3
Tumour excision	1	2
Totals	16	14

Patients randomised to Group A (even numbers) had their donor sites dressed with a single layer of calcium alginate impregnated with 0.25% plain bupivacaine. A generous overlap onto dry skin was ensured. This was overlaid with gauze, cotton wool and a bandage. Those randomised to Group B (odd numbers) were dressed with a single layer of silicone net overlaid with gauze and wool and secured with a bandage. The silicone net dressing was also overlapped onto dry skin and the wound was irrigated with 0.25% plain bupivacaine prior to applying the dressing. All grafts were harvested from the lateral aspect of the thigh using a Padgett[R] electric dermatome at a setting of 0.01 inches. This ensured as much as possible uniform thickness of the grafts harvested. An adrenaline soaked gauze was placed temporarily on each donor site for 10 minutes prior to applying the dressing.

Donor site healing was assessed at days 7, 10, 14 and up to day 21 by the first author (JOD). A donor site was classified as 100% healed if the wound had a dry reepithelialised surface. If it was noted to be unhealed then the dressing was replaced. Pain during the first dressing change was assessed using a 10 Visual Analogue Pain (VAP) scale (0 represented no pain and 10 the worst pain ever experienced). The presence of infection was assessed by routine culturing of wound swabs. Dressing slippage was also recorded at the first dressing change. Statistical significance was taken at the 5% level.

RESULTS

Sixteen patients were randomised to the calcium alginate group and 14 patients to the silicone net group. There were no significant differences in the gender distributions or age ranges between the two groups of patients (Table 2).

Tab. 2. Age and gender `distribution' of the study groups

	Calcium alginate	Silicone net
Males	9	7
Females	7	7
Age range	19-72 years	20-71 years
Mean age	49.9 years	46 years

All donor sites were healed by day 16 with a mean of 8.75 ± 0.78 (SEM) days for calcium alginate (range 7 to 14 days) and 12 ± 0.62 (SEM) days for silicone net (range 7 to 16 days) with t = 3.256, i.e. $p < 0.01$ (Table 3).

Tab. 3. Time to healing (in days)

	Calcium alginate	Silicone net
Range	7-14	7-16
Mean	8.75	12
SD	3.13	2.32
SEM	0.78	0.62

t = 3.256 at 28 DF
$p < 0.01$

The first two patients in the silicone net group scored 10 and 9 respectively on the VAP scale during the first dressing change. It was noted that the overlaid gauze had adhered to the unhealed donor site through the fenestrations of the silicone-coated dressing, thereby causing maximum discomfort on removal of the dressing. It therefore became necessary to change the trial protocol. Subsequent patients in the silicone net group were dressed with a layer of paraffin gauze placed over the silicone net in order to prevent the absorbent cotton gauze from sticking to the wound. Wilcoxan Rank sum and Student t tests for unpaired samples revealed no differences in pain perception between the two groups whether or not the first two patients in the silicone net group were included in the analyses, i.e. $p > 0.05$ (Table 4).

Tab. 4. VAP scores recorded during the first dressing change

VAP	Calcium alginate	Silicone net
Range	0-9	1-10
Mean	2.68	4.7
SD	2.65	2.61
SEM	0.66	0.725

$t = 2.104$ at 28 DF
$p > 0.05$
Zero represents no pain and 10 the worst possible pain

Although more silicone net than calcium alginate dressings slipped, this difference was not statistically significant (Table 5). There was only one proven infection in the study. This was a *Pseudomonas aerginosa* infection which occurred in the calcium alginate group.

Tab. 5. Dressing slippage rates

	Calcium alginate	Silicone net
Slipped dressing	1	5
Unslipped dressing	15	9

$x^2 = 2.419$ at 2 DF
$0.5 > p > 0.1$ NS

DISCUSSION

This study analyses time to healing, pain during dressing changes and slippage rates for two different dressings on split skin graft donor sites in a randomised prospectively controlled open trial. Silicone-coated polyamide net was the experimental dressing and calcium alginate was considered as the control because its efficacy in the healing of split skin graft donor sites has been clearly demonstrated in a number of previous studies (O'Donoghue, 1997; Attwood, 1989; Basse, 1992).

Ideally, blinding the donor site examiner to the dressings used would have added more weight to the study. However for logistical reasons, this was not possible in our unit. Nevertheless, study design is important if meaningful conclusions are to be drawn. For instance the introduction of strict exclusion (and inclusion) criteria is important in wound healing studies in order to reduce as much as possible the many variables which influence wound healing. However this results in difficulty recruiting large numbers of patients into such a study. Previous studies which have compared calcium alginate to other donor site dressings have also contained small numbers. Vanstraelen demonstrated significantly reduced healing times for calcium alginate when compared to porcine xenograft in a non randomised study of only 20 patients (Vanstraelen, 1992). There were no exclusion criteria applied in this study and grafts were harvested with a Watson knife. Although an electric dermatome does not guarantee uniformity of graft thickness it ensures as much as possible that variations in the depth of donor sites between individuals is reduced. We believe this is important when trying to assess healing efficacy. In the study by Basse et al only 17 patients were studied in a non randomised trial (Basse, 1992). The time to healing with the use of calcium alginate was reduced when compared to paraffin gauze. Attwood also demonstrated similar results in phase I of his trial in which only 15 patients were included (Attwood, 1989). He also makes the point that there is little point in proceeding with a trial if it is noted that one form of treatment is far superior to another. In our trial the time to healing was significantly longer in the silicone net group. Continuation of the trial would not have been ethically justified.

In the previous studies which compared calcium alginate with other experimental dressings it is interesting to note that the patients acted as their own controls. For instance, both Attwood and Vanstraelen dressed one half of the donor site with calcium alginate and the other half with another dressing (Attwood, 1989; Vanstraelen, 1992). We believe there are several shortcomings associated with the use of this design methodology. Firstly, it is difficult to assess patient discomfort to a dressing if both experimental dressings are in contact with one another. Secondly, dressing slippage is also difficult to assess as slippage may result from one dressing shearing off the other. Thirdly, it is difficult to be sure if epithelialisation near the edge of a dressing has resulted from healing in the adjacent region covered by the other dressing. This may account for the differences noted in healing times between the various studies for wounds covered with calcium alginate. Finally, assessing the likelihood of infection developing beneath a dressing is impossible, as the infection can easily spread from one covered area to an adjacent one. Therefore, we believe it is important when performing skin graft donor site trials to randomly allocate dressings to individual patients and to compare responses in one individual with responses in another.

Although one study supports the use of silicone-coated polyamide net dressing as a skin protective agent during irradiation (Adamietz, 1995), the authors noted that dressing displacement was a problem. Although there was no significant difference in the slippage rates between the two dressings used in our trial (Table 5), it is interesting to note that more dressings slipped in the silicone net group (5:1). As a result, the overlying gauze adhered to the wound surface, thus proving difficult and painful to remove.

Pain is a subjective experience and may vary greatly between patients, thus making it difficult to quantify. However, VAP scores have become accepted as a reliable method for measuring and comparing pain (Choiniere, 1994; Marvin, 1996). In this trial, no significant differences in VAP scores were noted between the two groups. However, it must be noted that the trial protocol was changed after the first two patients were randomised to the silicone net arm of the study.

Because the overlying absorbent gauze became adherent to the unhealed donor site through the fenestrations in the silicone-coated net, it was necessary to cover the net with paraffin gauze to prevent this from happening. This encouraged blood and exudate to collect beneath the dressing. This may have contributed to the slower healing times noted in this group of patients.

In this study we impregnated the calcium alginate with 0.25% plain bupivacaine and sprinkled it directly on the wound in the silicone net group. This has been shown in a previous study to significantly reduce postoperative donor site pain (Butler, 1993). Although the effects of bupivacaine on wound healing are unknown, it has been clearly shown that its use with calcium alginate does not interfere with the healing of split skin graft donor sites (Butler, 1993).

Silicone-coated polyamide net has been shown to be useful in fixing split skin grafts to the graft bed. In a non-controlled study in children almost all the grafts took completely and dressing changes were apparently well tolerated (Vloemans, 1994). In a randomised controlled trial comparing silicone net and paraffin gauze dressings in skin-grafted sites, dressing changes proved significantly less painful for those in the silicone net group while dressings proved significantly more difficult to remove in the paraffin gauze group (Platt, 1996). However, there would appear to be a lack of prospective randomised trials in the literature examining its use as a donor site dressing. In the present study we were unable to demonstrate improved healing efficacy of donor sites dressed with silicone-coated polyamide net when compared to calcium alginate. We also found no difference in the level of discomfort experienced by patients during the first dressing change. In addition, at the time of going to press, similar sized silicone net (Mepitel^{R}) is approximately twice as expensive as calcium alginate (Kaltostat^{R}) per unit issue.

Calcium alginate has proven in a number of trials to be a useful donor site dressing. We continue to use it as our dressing of choice and we would recommend that any future trials of potentially novel donor site dressings should include calcium alginate in the study design as the comparative control. We would not recommend the use of silicone-coated polyamide net as split skin graft donor site dressing.

ACKNOWLEDEMENTS

The authors would like to express their appreciation to both Britcair and Molynlycke for supplying the dressings for the trial. No financial contributions were offered or received. None of the authors had a financial interest in either company. There were no conflicts of interest.

REFERENCES

1. Adamietz, IA., Mose, S., Haberl, A., Saran, FH., Thilman, C., Bottcher, HD. Effect of self-adhesive, silicone-coated polyamide net dressing on irradiated human skin. *Rad. Oncol. Invest.,* 2: 277-282, 1995.

2. Attwood, Al. Calcium alginate dressing accelerates split skin graft donor site healing. *Br. J. Plast. Surg.,* 43: 375-379, 1989.

3. Basse, P., Siim, E., Lohmann, M. Treatment of donor sites - calcium alginate versus paraffin gauze. *Acta Chir. Plast.,* 34: 92-98, 1992.

4. Butler, PEM., Eadie, PA., Lawlor, D., Edwards, G., McHugh, M. Bupivacaine and Kaltostat reduces postoperative donor site pain. *Br. J. Plast. Surg.,* 46: 523-524, 1993.

5. Choiniere, M., Auger, FA., Latarjet, J. Visual analogue thermometer: a valid and useful instrument for measuring pain in burned patients. *Burns,* 20: 229-235, 1994.

6. Marvin, JA., Muller, MJ., Blakney, PE., Meyer, WJ. Pain response and pain control. In: Herndon, DN. (ed.), *Total Burn Care.* Philadelphia: W. B. Saunders, 1996: 529-543.

7. O'Donoghue, JM., O'Sullivan, ST., Beausang, ES., Panchal, JI., O'Shaughnessy, M., O'Connor, TPF. Calcium alginate dressings promote healing of split skin graft donor sites. *Acta Chir. Plast.,* 39: 53-55, 1997.

8. Platt, AJ., Phipps, A., Judkins, K. A comparative study of silicone net dressing and paraffin gauze dressing in skin-grafted sites. *Burns,* 22: 543-545, 1996.

9. Vanstraelen, P. Comparison of calcium sodium alginate (Kaltostat) and porcine xenograft (E-Z DERM) in the healing of split-thickness skin graft donor sites. *Burns,* 18: 145-148, 1992.

10. Vloemans, AFPM., Kreis, RW. Fixation of skin grafts with a new silicone rubber dressing (Mepitel). *Scand. J. Plast. Reconstr. Hand Surg.,* 28: 75-76, 1994.

Address for correspondence:

Mr. J. M. O'Donoghue, M. Med. Sci.,
M. Ch., FRCSI (Plast.),
Consultant Plastic Surgeon,
Department of Plastic Surgery,
St. George's Hospital,
Blackshaw Road,
Tooting,
London SW17 OQT,
England

PHYSIOLOGICAL DIFFERENCES FOR DISTINCT SOMATIC SENSORY MODALITIES AND SWEATING AMONG THE DONOR SITES OF CUTANEOUS AND FASCIOCUTANEOUS FREE FLAPS

Ahčan U., Arnež Z. M., Kristan A.

University Department of Plastic Surgery and Burns, University Medical Centre Ljubljana, Slovenia

SUMMARY

Differences of sensation and sweating among the typical sites of cutaneous and fasciocutaneous flaps (scapular, lateral arm, radial forearm, groin and dorsalis pedis) were assessed in 30 healthy volunteers (20 males and 10 females) aged 17-62 years (mean 38.2 years). Standard clinical methods were used: Semmes-Weinstein monofilaments for testing light touch threshold, discriminator and blunt caliper for evaluation of static and dynamic two-point discrimination and the Marstock quantitative method for assessing the normative values of warm-cold difference limen and heat and cold pain thresholds. Spontaneous sweat secretion was observed and documented by the ninhydrin test.

We established various physiological differences for distinct somatic sensory modalities and sweating among the body regions (donor sites of cutaneous and fasciocutaneous free flaps).

ZUSAMMENFASSUNG

Die physiologischen Unterschiede in der Empfindlichkeit und dem Schwitzen an den typischen Entnahmestellen der freien Haut- und Fasziokutannlappen

Ahčan U., Arnež Z. M., Kristan A.

Bei 30 gesunden Freiwilligen (20 Männer und 10 Frauen) im Alter von 17 bis 62 Jahren (Durchschnittsalter 38,2 Jahre) wurden die Unterschiede in der Empfindlichkeit und dem Schwitzen an den typischen Entnahmestellen der Haut- und Fasziokutannlappen (von der Schaufel, der lateralen Seite des Oberarmes, der radialen Seite des Unterarmes und von der Lohe und dem Fußbrücken) beobachtet.

Es wurden die standarten klinischen Methoden angewandt: die Semmes-Weinstein's Methode für den Test der weichen Berührung mit Anwendung der monofilen Faser, die stumpfe Schublehre für die Auswertung der statischen und dynamischen Unterscheidung der zwei Punkte und die Marschtock's kvantitave Methode für die Bestimmung der Unterscheidungsnormen der Wärme und Kälte und der Wärm- und Kälteschmerzschwelle. Die spontane Schweißsekretion wurde beobachtet und dokumentiert anhand des Ninhydrinstestes.

Die Autoren setzten fest die physiologischen Unterschiede in der Empfindlichkeit und dem Schwitzen zwischen den genannten Körperteilen (der Entnahmestellen der freien Haut- und Fasziokutannlappen).

Key words: sensation, sweating, cutaneous and fasciocutaneous free flaps

With the development of microvascular surgery, the distant transfer of large skin/fasciocutaneous flaps has become an important part of reconstructive surgery. Free flaps provide soft-tissue coverage, vascularity and sensibility to the injured site (Lee, 1992).

The selection and quality of free flaps depend on their appearance (thin, pliable), the length and the diameter of the vascular pedicle, their accessibility, their possibility to be innervated and the aesthetic/functional problems created at the donor site (Webster, 1988).

Problems of blood supply dominate all aspects of flap design and transfer. Skill in the design and use of flaps is very much a matter of balancing the demands of flap blood supply against those of flap geometry (McGregor, 1989).

Beside an appropriate vascular background, the selection of an appropriate flap donor site also based on the need for fine discriminatory or protective sensation, which is important for optimal results (Lee, 1992). The present era is the results of continuing efforts to improve detailed function and aesthetics (Boyd, 1994). Flap selection for reconstruction of skin/soft tissue defects is still a challenging problem to the plastic surgeon (Boyd, 1994; Chang, 1986). Sensation in those specific regions has a vital impact on function and quality of life.

It is therefore important to evaluate the neurosensory potential of different described flaps as well as the long-term sensory ability following transfer.

We believe that the recovery of distinct somatic sensory modalities has different impacts on final function. Warm-cold difference limen and heat and cold pain thresholds are more important in flap selection for oromandibular reconstruction; discriminatory sensation and vegetative function seem to be more important in reconstruction of the palm and sole.

Comparison with the equivalent area on the contralateral uninjured digit is an accurate way of expressing outcome, when assessing the results of peripheral nerve repair in replantation (Calder, 1993).

Data about distinct somatic sensory modalities and sweating of different typical donor sites for cutaneous and fasciocutaneous free flaps are therefore also important for estimating the final functional results (flap reinnervation) after surgery.

The purpose of this study is to assess the differences in sensation and sweating among the typical sites of some often used cutaneous and fasciocutaneous free flaps (scapular, lateral arm, radial forearm, groin and dorsalis pedis).

SUBJECTS AND METHODS

Subjects

The study was approved by the National Committee for Medical Ethics. Thirty healthy adolescents and adults, 20 males and 10 females aged 17-62 years (mean 38.2 years), were included in the study.

Methods

The testing began following a thorough description of the experiment to the patient. Sensation and sweating were evaluated at typical donor sites of cutaneous and fasciocutaneous flaps (scapular, lateral arm, radial forearm, groin and dorsalis pedis), palm and sole.

The two-point discrimination threshold test utilised a blunt caliper to determine the minimum distance at which the two points of contact could be distinguished from a single one (Woodward, 1987).

Static two-point discrimination for evaluation of the innervation density of the slowly adapting fiber-receptor system and moving two-point discrimination for evaluation of the innervation density of the quickly adapting fiber-receptor system were performed using standard tachniques (Omer, 1980).

To quantify the cutaneous pressure threshold (the stimulus intensity required to initiate an impulse) of the slowly adapting fiber receptors, we used Semmes-Weinstein monofilaments (HAND SET sensory testing nylon filaments, Gills W. Long Hansen's disease center, Cerville, Louisiana, USA). The Semmes-Weinstein monofilaments pressure aesthesiometer, which consists of a series of 8 probes marked 2.83 to 6.65, was applied manually to the skin surface. The number represents the logarithm of 10 times the force in miligrams required to bow the monofilament (Omer, 1980). The patients closed their eyes while we touched the skin with a monofilament. When the patients felt the pressure, they opened their eyes and localised the touch point with their index finger. Monofilaments were applied three times. If the patient missed the same monofilament twice in the same area, a larger monofilament was selected.

The Marstock method for the quantitative assessment of warm and cold temperature pain estimation was used. Subjective thresholds for warm and cold sensation and heat- and cold-induced pain were measured during delivery of ramps of relatively low or high temperature stimuli using a Quantitative SOMEDIC Thermotest device (Somedic AB, Stockholm, Sweden). A Peltier type thermode measuring 25 mm x 50 m was applied to the thenar eminence, sole and typical sites for scapular, lateral arm, radial forearm, groin and dorsalis pedis flaps. The temperature of the thermode could either rise or fall from the adapting temperature of 30 °C at various rates, depending on the direction and intensity of the current flow through the device. The temperature range of the probe was 10 - 50 °C. The subject held a switch in the free hand, which was to be pressed at the first sensation of either warmth or cold and heat or cold pain. A chart recorder registered temperature changes over time. At each site four consecutive responses were recorded. The rates of temperature change were 0.15 °C/s when detecting the warm-cold difference limen (WCDL) and 1 °C/s when detecting heat (HPT) and cold pain thresholds (CPT). In order to reduce variability, experimental conditions, including the physiological and mental state of the subjects, were carefully controlled.

The spontaneous sweat secretion was observed and documented by the ninhydrin test using a standard technique (Ahčan, 1997). The results of the ninhydrin test were classified by the intensity of the print pattern.

The absolute values of quantitative sensibility (thresholds) tended to fluctuate considerably among the subjects, therefore we used basic statistical analysis: the setting of numerical values into ranges. For each volunteer absolute values of distinct somatic sensory modalities (thresholds) from different body regions (free flap donor sites) were ordered into ranges from 1 to 7. The results were expressed by the mean value of ranges calculated from all volunteers.

RESULTS

Our results confirmed the existence of physiological differences for distinct somatic sensory modalities and sweating among the donor sites of cutaneous and fasciocutaneous free flaps. The two-point discrimination threshold, the cutaneous pressure threshold, the thresholds for warm and cold sensation and heat- and cold-induced pain, and sweating varied among the subjects and within body regions (donor sites for cutaneous and fasciocutaneous free flaps).

Static and dynamic two-point discrimination thresholds were lowest on the palm and sole, the dorsalis pedis, the radial forearm and the lateral arm free flaps. The highest two-point discrimination thresholds were observed in the groin and scapular regions.

Cutaneous pressure thresholds were lower on the lateral arm and radial forearm free flaps and in the palm, groin and scapular regions when compared to the sole and the region of the dorsalis pedis free flap.

The regional variability in the detection of small **temperature** variations (subjective thresholds for warm and cold sensations) was considerable. Greater sensitivity for cold and warm perception thresholds (warm-cold difference limen - WCD) was found on the palm, the lateral arm and radial forearm free flaps, and the groin. Thermal sensitivity was worse on the sole and in the scapular region and the region of dorsalis pedis free flap.

The most sensitive body regions for cold pain were the groin, the radial forearm and the lateral arm free flaps and the scapular region, followed by the palm, the region of the dorsalis pedis free flap and the sole. Greater sensitivity for heat pain was found in the region of the radial forearm free flap, the groin, the region of the dorsalis pedis free flap and the scapular region. Lower sensitivity for heat pain was found on the sole,

Table 1. Quantitative sensibility for distinct somatic sensory modalities in different body regions (expressed in mean values of ranges)

s 2PD		d 2PD		Pressure threshold		WCD		CPT		HPT	
palm	1.21	palm	1.29	palm	3.91	palm	1.93	sole	3.62	palm	4.85
sole	2.15	sole	2.35	sole	5.06	sole	5.23	palm	5.38	sole	5.92
DPff	3.35	Dpff	3.35	LAff	2.97	LAff	2.96	Gff	2.65	RFff	2.85
RFff	3.85	RFff	4.12	RFff	3.12	RFff	3.00	RFff	2.88	Gff	3.23
LAff	4.85	LAff	5.05	Gff	3.35	Gff	3.96	LAff	3.50	DPff	3.42
Gff	5.76	Gff	5.53	Sff	4.74	DPff	4.91	Sff	3.62	Sff	3.73
Sff	6.44	Sff	6.29	DPff	4.91	Sff	5.23	DPff	5.19	LAff	4.15

s 2PD = static two-point discrimination, d 2PD = dynamic two-point discrimination, WCD = warm-cold difference limen, CPT = cold pain threshold, HPT = heat pain threshold, DPff = dorsalis pedis free flap, RFff = radial forearm free flap, LAff = lateral arm free flap, Gff = groin free flap, Sff = scapular free flap

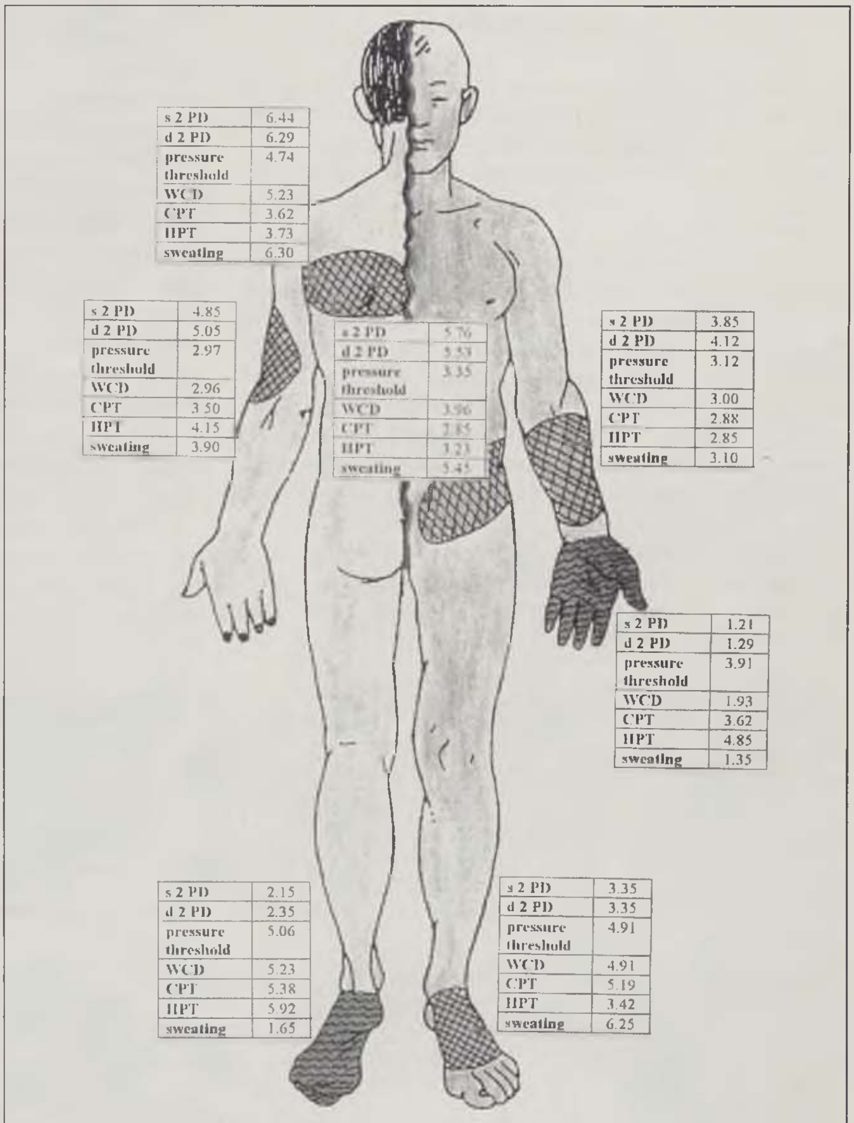

Fig. 1. Quantitative sensibility for distinct somatic sensory modalities and sweating between the donor sites for cutaneous and fasciocutaneous free flaps (mean values of ranges); s 2PD = static two-point discrimination, d 2PD = dynamic two-point discrimination, WCD = warm-cold difference limen, CPT = cold pain threshold, HPT = heat pain threshold.

Table 2. Spontaneous sweat secretion in different body regions (expressed in mean values of ranges)

palm	1.35	soles	1.65	RFff	3.10	LAff	3.90	Gff	5.45	DPff	6.25	Sff	6.30

palm and the region of the lateral arm free flap.

The results for distinct somatic sensory modalities in different body regions (typical sites for cutaneous and fasciocutaneous) flaps are collected and shown in Table 1 and Figure 1.

The most intensive ninhydrin print pattern, which reflects spontaneous sweat secretion, was observed on the palms and soles, the forearm, the region of the lateral arm free flap and the groin. Less sweating was documented in the scapular region and on the dorsum of the foot. The results of sweating in different body regions are shown in Table 2 and Figure 2.

DISCUSSION

Human skin provides a large surface area in contact with the environment. Numerous stimuli from the skin, especially from the glabrous prehensile hand, are transmitted to the brain, permitting man's present eminence on earth (Serafin, 1991).

The receptors for somatic sensation are distributed throughout the body, therefore the somatic sensibilities are called the skin senses or body senses. There are four distinct somatic modalities: touch (elicited by mechanical stimulation of the body surface), pain (elicited by noxious stimuli), thermal sensations (elicited by cool and warm stimuli) and proprioceptive sensations (elicited by mechanical displacement of muscles and joints).

Pain is mediated by mechanical, thermal and polymodal nociceptors. Warmth and cold are mediated by thermal receptors that form cold and warm spots. Touch is mediated by slowly and rapidly adapting mechanoreceptors, which vary in the size of their receptive field, their rate of adaptation to stimuli and their ability to resolve spatial and temporal features of stimuli (Martin, 1991).

In addition to these elementary modalities, there are many submodalities. We can distinguish several forms of tactile sensation, such as superficial touch and deep touch or static and dynamic forms of limb proprioception. Furthermore, there are also compound sensations realised by combining elementary modalities and submodalities in different ways (Martin, 1991).

There is a large variety of morphologically distinct somatic sensory receptors with different physiological characteristics throughout the human body (Martin, 1991).

Hairy skin (more than 90 % of the body surface) and glabrous skin have different types of mechanoreceptors, different complexities in the arrangement of sensory nerves, different proportions of myelinated fibres, and different densities of vegetative fibers and sweat glands (Serafin, 1991; Halata, 1993).

The human palmar skin is recognised for the diversity and high concentration of its sensory receptor organs and for its high degree of sensibility and sensitivity compared to more proximal cutaneous areas of the upper extremity and the trunk (Cauna, 1980; Mouncastle, 1974).

In the management of peripheral nerve problems, some attempts have been made to examine sensibility in quantitative terms (Omer, 1980).

The stimulus intensities required to initiate an impulse (the cutaneous pressure threshold) of the slowly adapting fiber receptors using the Semmes-Weinstein monofilaments were accurately established for the hand (Werner, 1970)

2a) 2b) 2c)

Fig. 2. The most intensive ninhydrin print pattern, which reflects spontaneous sweat secretion, was observed on the palm (a) and soles (b), the forearm, and the region of the lateral arm free flap (c).

and on the right and left sides of 20 body parts in males (Weinstein, 1968).

Spatial discrimination quantified by two-point discrimination varies between different body regions, from about 2 mm on the finger to 43 mm on the back and 50 mm on the calf (Martin, 1991).

The normative values of warm-cold difference limens and heat and cold pain thresholds in nine parts of the body in healthy volunteers have also been determined (Meh, 1993).

Nevertheless, the literature contains no data about the physiological differences for distinct somatic sensory modalities and sweating among the sides for cutaneous and fasciocutaneous free flaps.

Nowadays, appropriate selection of flap donor sites based on the need for fine discriminatory or protective sensation is important for optimal results (Lee, 1992).

Cutaneous and fasciocutaneous free flaps represent thin pliable soft-tissue, rich microvasculature with a sufficient blood supply and different types and numbers of free nerve endings and sensory receptors, sweat glands and vegetative innervation. Beside appearance, pedicle length and diameter and other aspects of flap design and transfer, it is worthwhile to know the quantitative sensibility of the free flap prior to surgical reconstruction.

Flap selection for reconstruction of soft defects on the posterior heel, Achilles tendon, maleolli and sole, the oromandibular region and the palm is still a challenging problem for the plastic surgeon (Boyd, 1994; Gang, 1987). Furthermore, the sensation of specific regions such as the oral cavity, palm and sole has a vital impact on function and quality of life after reconstruction.

The results of our study confirmed the existence of physiological differences for distinct somatic sensory modalities and sweating among the donor sites for cutaneous and fasciocutaneous free flaps.

The two-point discrimination threshold, the cutaneous pressure threshold, the subjective thresholds for warm and cold sensation and heat- and cold-induced pain and sweating varied among the subjects and within the body regions.

The dorsalis pedis and the radial forearm free flaps seem to have the best sensory potential and thus can provide the best reconstructive choice for restoration of critical sensibility in mutilating hand (palm) injuries where fine discriminatory sensation is important. The most intensive sweating, which is also important for the final functional outcome of an injured hand, was documented in the region of the radial forearm free flap.

For intraoral reconstruction the most appropriate free flaps seem to be the radial forearm, the lateral arm and the groin free flaps, which are the most sensitive for small temperature variations (warm-cold difference limen) and heat and cold pain.

We know that sensory acuity is not simply proportional to the number of sensory receptors and free nerve endings. Furthermore, the thresholds of sensory units vary for many reasons. Sensibility is affected by the receptors (the condition of the overlying epithelium, circulation and temperature in the area of the receptor, specific morphology and adaptability), by the afferent pathway system (inhibitory and facilitatory effect on transmission and summation) and by the sensory cortex (attention and concentration of the individual, spatial-temporal pattern of impulse input, stored memory and experience, coordination with vision and hearing, selection and erasure of irrelevant information) (Omer, 1980).

Furthermore, data about free flap reinnervation and nerve regeneration within the preexisting neural structures in free flaps are controversial. It has been demonstrated that an axon will grow less than 1 mm in the absence of these supporting elements and that reinnervation of any tissue requires available Schwann cell pathways to guide the transected axons back to a receptor organ (Dykes, 1987).

The ingrowth of a newly sprouting axon in an empty tube of a former degenerated nerve was also found in noninnervated myocutaneous free flaps (Turkof, 1993). Therefore, the donor tissue and its nervous content are important for the final outcome of flap reinnervation and sensory and vegetative function.

A high sensory potential for distinct somatic sensory modalities is just one of the factors that influence the restoration of sensibility in the free flap following surgical repair.

The healthy denervated skin of free flaps provides a strong neurotrophic stimulus to the cut cutaneous nerves at the edges of the recipient skin. Therefore, the importance of the recipient site to the sensory and vegetative reinnervation of cutaneous and fasciocutaneous noninnervated free flaps should be evaluated.

As reconstructive surgeons attempt to restore sensibility using free flap transfers, it is critical to have a clear understanding of the patterns and mechanisms of sensory recovery. Such an understanding will allow us to choose the most appropriate donor site for free flaps (Mackinnon, 1978).

To the selection and quality of free flaps, which are mostly based on their appearance (thin, pliable), pedicle length and diameter, accessibility, possibility to be innervated and potential donor site defects, we suggest to add distinct somatic modalities and sweating in quantitative terms.

REFERENCES

1. Ahčan, U., Arnež, ZM., Janko, M., Dovšak, D. Regeneration of sudomotor and sensory nerve fibers after digital replantation and microneurovascular toe-to-hand transfer. *Br. J. Plast. Surg.*, 50: 227-235, 1997.

2. Boyd, B., Mulholland, S., Gullane, P., Irish, J., Kelly, L., Rotstein, L., Brown, D. Reinnervated lateral antebrachial

cutaneous neurosome flaps in oral reconstruction. Are we making sense? *Plast. Reconstr. Surg.,* 93, 7: 1350-1359, 1994.
3. Calder, JS., McAllister, RMR. Interpreting the results of unilateral digital nerve repair. *J. Hand Surg.*, 18B: 797-799, 1993.
4. Cauna, N. Fine morphological characteristics and microtopography of the free nerve endings of the human digital skin. *Anat. Record.,* 198: 643-656, 1980.
5. Chang, KN., DeArmond, SJ., Bunckle, H. Sensory reinnervation in microsurgical reconstruction of the heel. *Plast. Reconstr. Surg.,* 78: 652-663, 1986.
6. Dykes, W. Discussion. The recovery of sensory function following skin flaps in humans. *Plast. Reconstr. Surg.,* 79, 3: 434-5, 1987.
7. Gang, RK. Reconstruction of soft-tissue defect of the posterior heel with a lateral calcaneal artery island flap. *Plast. Reconstr. Surg.,* 79, 3: 415-419, 1987.
8. Halata, Z. Sensory innervation of the hairy skin (light- and electronmicroscopic study). *J. Investigat. Dermatol.,* 101, 1: 75-81, 1993.
9. Lee, WP., May, JW., Jr.: Neurosensory free flaps to the hand. Indications and donor selection. *Hand Clinics,* 8, 3: 465-477, 1992.
10. Mackinnon, SE. Discussion - Sensibility and cutaneous reinnervation in free flaps. *Plast. Reconstr. Surg.,* 79, 3: 426-427, 1987.
11. Martin, JH., Jessel, TM. Modality coding in the somatic sensory system. In Kandel, ER., Jessel, TM. (Eds) *Principles of neural science.* East Norwalk : Appleton & Lange, 1991.
12. McGregor, IA. *Fundamental techniques of plastic surgery and their surgical applications.* Edinburgh : Churchill Livingstone, 1989.
13. Meh, D., Denišlič, M. Warm, cold and pain estimation. *Zdrav. Vestn.,* 62: 445-450, 1993.
14. Mouncastle, VB. *Medical physiology.* 13th ed. Saint Louis : Mosby, 1974.
15. Omer, GE., Spinner, M. Sensibility testing. In Omer, GE., Spinner, M. (Eds): *Management of peripheral nerve problems.* Philadelphia : Saunders, pp. 3-16, 1980.
16. Serafin, D. The skin. Functional, metabolic and surgical considerations. In Sabiston, DC. (Ed.): *Textbook of surgery. The biological basis of modern surgical practice.* Philadelphia : W. B. Saunders, pp. 1382-1389, 1991.
17. Turkof, E., Jurecka, W., Sikos, G., Piza-Katzer, H. Sensory recovery in myocutaneous, noninnervated free flaps: A morphologic, immunohistochemical, and electron microscopic study. *Plast. Reconstr. Surg.,* 92, 2: 238-247, 1993.
18. Webster, MHC., Soutar, DS. *Practical guide to free tissue transfer.* London : Butterworths, 1988.
19. Weinstein, S. Intensive and extensive aspects of tactile sensitivity as a function of body part, sex, and laterality. In Kenshalo, DR. (Ed.): *The skin senses.* Springfield : Thomas, 1968.
20. Werner, JL., Omer, GE., Jr. Evaluating cutaneous pressure sensation of the hand. *Am. J. Occup. Ther.,* 24: 347, 1970.
21. Woodward, LK., Kenshalo, R. The recovery of sensory function following skin flaps in humans. *Plast. Reconstr. Surg.,* 79: 428-433, 1987.

Address for correspondence:

Zoran M. Arnež, MD., PhD.
University Department of Plastic Surgery and Burns
University Medical Centre Ljubljana
Zaloška 7
SI-1525 Ljubljana,
Slovenia

CASE REPORT: A FREE ARTERIALIZED VENOUS FLAP FOR INTRAORAL CANCER RECONSTRUCTION

Cunha-Gomes D., Bhathena H., Kavarana N. M.

Plastic & Reconstructive Surgical Service, Tata Memorial Hospital, Parel, Mumbai, India

SUMMARY

The free arterialized cephalic venous flap is a good option for intraoral reconstructions. It offers thin, pliable skin as a one-stage transfer without sacrifice of a major artery. The radial dominant hand poses a problem, which can be surmounted by this flap.

ZUSAMMENFASSUNG

Die Beschreibung eines Falles: der freie arterialisierte Venoslappen fâr die Rekonstruktion des intraoralen Krebs

Cunha-Gomes D., Bhathena H., Kavarana N. M.

Der freie arterialisierte Venoslappen ist eine richtige Wahl für die intraorale Rekonstruktion. Er bietet an eine dânne und nachgiebige Haut für die eingradige Übertragung, ohne die große Artherie opfern zu müssen. Die radial dominante Hand stellt ein Problem dar, das mithilfe dieses Lappens überwunden werden kann.

Key words: arterialized venous flap, intraoral reconstruction

Since Nakayama's report in 1981 (1), arterialized venous flaps have been utilized in experimental and clinical cases. Various authors have reported the usefulness of this flap in their reconstructive efforts (1-9). The venous forearm flap has many significant advantages over the radial artery forearm flap.

We present a case where a free arterialized venous flap was done for an intraoral reconstruction.

CASE DETAILS

A 45-year-old male, a chronic tobacco chewer, had an ulcerative growth over the Rt. buccal mucosa, which on biopsy proved to be a well-differentiated squamous cell carcinoma. The ulcer was free from the cheek skin and did not extend into the upper or lower buccal sulci (Fig. 1).

A wide excision of the buccal mucosa with a Rt. supraomohyoid dissection was done. On frozen section the margins were not involved. The mandible was intact.

It was decided to resurface the defect by a free radial forearm flap. However, a preoperative Allens test on the upper extremities indicated a radial dominant hand.

A free venous flap was marked on the forearm of the non-dominant upper extremity. The paddle of skin, 7x5 cms was marked centred over the

Fig. 1. Preoperative photograph: Rt. Buccal mucosal squamous cell carcinoma.

Fig. 2. Venous flap being harvested.

cephalic vein. An extra vein draining the flap was harvested in addition (Fig. 2).

Under tourniquet, the flap was elevated in a plane below the deep fascia. This prevents damage to the veins, which lie superficial to the deep fascia. The flap was transferred to the defect and then tagged into position.

The distal end of the cephalic vein was anastomosed to the facial artery in the neck. The proximal veins were anastomosed to the common facial vein and the external jugular vein. On releasing the vascular clamps the flap edges bled well. The donor defect was resurfaced by a thick split thickness graft.

Fig. 3. Postoperative photograph.

Postoperatively the flap settled down well (Fig. 3). Oedema in the flap took 2 months to settle down. The donor site healed well.

DISCUSSION

Reconstruction of buccal mucosa where the cheek skin and the mandible is intact necessitates a thin pliable paddle of skin. Skin grafts, though the easiest solution, often lead to a host of problems including contracture and trismus. Regional flaps are very bulky, disfiguring (pectoralis major myocutaneous flap) and may be associated with poor aesthetics of the donor area (forehead flap).

The radial forearm flap is well suited to these defects. However, its disadvantages include the removal of an important arterial channel of the hand and forearm. This flap is not harvested in a radial dominant hand. (Indicated by a preoperative Allens test.) This was the situation in this case. Poor graft 'take' over the donor area on the forearm on many occasions constitutes another major disadvantage.

On the other hand the free arterialized venous flap constitutes a good alternative as:

1. the radial artery is not sacrificed;
2. the skin paddle is placed higher on the forearm. Therefore the skin graft 'take' is much better.

Nakayama et al. and Thatte et al. have explained that tissue oxygenation occurs from the venous vascular plexus, the arterial side being free of blood. This is quite different from the normal circulatory pattern: artery - capillary - tissue - venule - vein (1, 10).

Klein, in a series of 29 patients, had complete flap survival in 52 % of cases (9). The high morbidity of this flap has been attributed to its vascular pecularity. Flap failures can be minimised if more than one outflow channel from the paddle is anastomosed and the skin paddle limited to 45-50 square cms (7, 9).

It must be noted that, by this procedure, an arteriovenous fistula is produced. Though small in magnitude, its harmful effects like bradycardia and hypertension should be anticipated.

The basic understanding of flap perfusion in venous flaps is to be decisively understood and demonstrated. Notwithstanding, this flap has the potential of being an excellent modality for intraoral reconstructions due to its thin and pliable characteristics and minimal donor site morbidity. In view of the ease of harvest and large calibre of vessels for anastomosis, the arterialized venous flap is sure to become an important reconstructive option for facial and intraoral defects.

REFERENCES

1. Nakayama, Y., Soeda, S., Kasai, Y. Flaps nourished by arterial inflow through the venous system. *Plast. Reconstr. Surg.*, 67: 328, 1981.

2. Voukidis, T. An axial pattern flap based on the arterialized venous network: an experimental study in rats. *Br. J. Plast. Surg.*, 35: 524, 1982.

3. Inoue, G., Maeda, N., Suzuki, K. Arterialized venous flap coverage for skin defects of the hand and foot. *J. Reconstr. Microsurg.*, 4: 23, 1988.

4. Koshima, I., Soeda, S., Nakayama, Y., Fukuda, H., Tanaka, J. An arterialized venous flap using the long saphenous vein. *Br. J. Plast. Surg.*, 44: 23, 1991.

5. Chen, HC., Tang, YB., Noordhorf, MS. Four types of venous flaps for wound coverage: A clinical appraisal. *J. Trauma.*, 31: 1286, 1991.

6. Yilmaz, M., Menderes, A., Karaca, C., Barutcu, A. Free arterialized venous forearm flap. *Ann. Plast. Surg.*, 34: 88, 1995.

7. Galumbeck, MA., Freeman, BG. Arterialized venous flaps for reconstructing soft tissue defects of the extremities. *Plast. Reconstr. Surg.*, 94: 997, 1994.

8. Yilmaz, M., Mederes, A., Karatas, O., Karaca, C., Barutcu, A. Free arterialized venous forearm flaps for limb reconstruction. *Br. J. Plast. Surg.*, 49: 396, 1996.

9. Klein, C., Kovacs, A., Stuckensen, T. Free arterialized venous forearm flaps for intraoral reconstruction. *Br. J. Plast. Surg.*, 50: 166, 1997.

10. Thatte, MR., Thatte, RL. Venous flaps. *Plast. Reconstr. Surg.*, 91: 747, 1993.

Address for correspondence:

Dr. Dean Cunha-Gomes,
Flat 3, Skyscraper - A,
Breach Candy,
Mumbai - 400 026,
India

CO_2 AND Nd:YAG LASER-ASISSTED NERVE REPAIR: A STUDY OF BONDING STRENGTH AND THERMAL DAMAGE

Menovsky T.

Department of Neurosurgery, University Hospital Nijmegen St Radboud, Nijmegen, and Laser Center, Academic Medical Center, Amsterdam, The Netherlands

SUMMARY

To improve the laser welding procedure, a comparative study was undertaken to investigate the acute bonding strength and the thermal damage following CO_2 and Nd:YAG laser-assisted nerve repair, performed with and without the use of blood and/or albumin as a solder. The strongest welds were produced with the CO_2 laser using albumin as a solder. Thermal damage was minimal with the CO_2 laser, whereas the damage with the Nd:YAG laser was substantial. The high bonding strength combined with minimal thermal damage of the nerve following repair with the CO_2 laser with the use of albumin justify further investigations using this technique in *in vivo* studies.

ZUSAMMENFASSUNG

CO_2 und Nd:YAG Laserassistenz bei Nervenerneurung: eine Studie über die Verbindungsstärke und Thermobeschädigung

Menovsky T.

Die Vergleichsstudie wurde wegen der Verbesserung der Laserschweißung verfertigt. Sie untersucht den kritischen Charakter der Verbindungsstärke und Thermobeschädigung infolge der CO_2 und Nd:YAG Laserassistenz bei Nervenerneureung, die mit oder ohne Anwendung des Blutalbumins als Lot durchgeführt wurde. Die stärksten Verbindungen wurden mit dem CO_2 Laser, der das Albumin als Lot benutzt, erreicht. Die geringste Thermobeschädigung folgte nach der Anwendung des CO_2 Lasers, wobei nach der Anwendung des Nd:YAG Lasers folgte eine ernsthafte Beschädigung. Die hohe Verbindungsstärke kombiniert mit einer minimalen Nervenbeschädigung infolge der Erneurung durch den CO_2 Laser bei der Anwendung des Albumins berechtigt die weiteren Untersuchungen der Anwendung dieser Technik bei Studien *in vivo*.

Key words: peripheral nerve, laser surgery, tissue welding, tensile strength

Experimental nerve repair by laser has certain advantages over conventional microsurgical nerve repair (CMSR), such as minimal foreign body reaction, less neuroma formation, and a faster repair procedure (20). Nevertheless, the clinical application of laser-assisted nerve repair (LANR) is limited by a high dehiscence rate (15, 17) and unpredictable results.

Many factors influence the bonding strength and thermal damage of laser welded nerves, such as wavelength, amount of laser energy deposited at the tissue, and technique that is used. Moreover, various protein solders have been used in vessel (8), urethra (23), and nerve laser welding (21). These solders, which provide extra proteins for the fusion process, are welded on the outer surface of the repair site to hold the tissue together and thus results in stronger welds and therefore lower dehiscence rates. Moreover, they might act as a heat sink, reducing the thermal damage of the irradiated tissue.

Far of the most experimental work LANR has been performed with the CO_2 laser (1 = 10,640 nm) (3, 4, 10, 12-16, 19, 26). However, also the Nd:YAG laser at wavelengths of 1,064 and 1,320 nm has been successfully used for microsurgical repair of arteries (5), veins (6), vas deference (1), and nerves (25). Which of these lasers and techniques is the best for microneural repair still remains to be proved, as comparative data are lacking. Because of the great variability of the laser parameters and techniques reported in the literature, the choice of an efficient set of laser parameters to perform nerve repair is difficult.

The aim of this study was to define more closely the optimal conditions (laser wavelength and technique) for laser nerve repair in terms of bonding strength and thermal damage before progressing to survival experiments. Two different lasers were employed (CO_2 and Nd:YAG laser), both with and without addition of a chromophore and/or solder (albumin) to serve as an adjunct to the welding process.

MATERIALS AND METHODS

Male Wistar rats (weighing 250-300 g) were used for this study. The rats were housed maximal six to a cage and were kept during the experiments under conventional laboratory conditions. Before surgery, general anesthesia was accomplished by intraperitoneal injection of ketamine-xylazine mixture (4:3), at a dosage of 0.15 ml/100 g. In each rat, the right sciatic nerve was exposed through a dorsolateral incision (18) and by stomp cleaving the overlying hamstring muscles. Under the operating microscope (25x magnification), the nerves were dissected free of the connective tissue and isolated from the surrounding tissue by a plastic sheet.

Bonding Strength Study

For determination of the bonding strength following laser welding, the nerves were divided by sharp microscissors and both nerve ends were trimmed. In the laser alone group (group I, n = 12), the nerve ends were closely approximated, and the epineurium of one of the nerve sections was pulled over the nerve end of the other nerve section and welded around its circumference with repeated single spots of laser energy (Fig. 1a). In this group, the nerves were repaired either with the CO_2 laser (n = 6) (Cooper LS 860, Cooper LaserSonics Inc., Santa Clara, CA, λ = 10,640 nm), or the Nd:YAG laser (n = 6) (SLT, Model CL 60, Malvern, PA, λ = 1,064 nm). The end point of the welding procedure was defined as the visible fusion of the both epineuria of the nerves, which was accompanied by a slight white, brown-yellow discoloration of the welded tissue.

In the laser and chromophore group (group II, n = 6), the nerve ends were closely approximated, and blood was applied in a thin coat to the repair site before laser welding. The nerve was then welded around its circumference with repeated single spots of Nd:YAG laser energy (Fig. 1b). The blood as a chromophore was used to enhance laser absorption within the tissue. As the CO_2 laser does not require a chromophore for laser absorption, we excluded the CO_2 laser from this group of laser repair.

The third group of laser repair was performed in the same fashion as group II, except that albumin powder diluted in saline was added to the chromophore (group III, n = 12). For the CO_2 laser (n = 6), only albumin solution was added to the repair site.

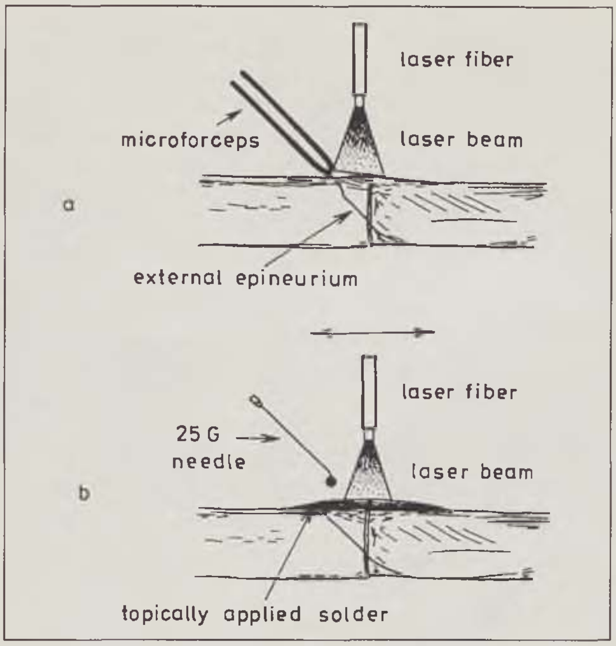

Fig. 1. The procedure of **laser assisted nerve repair**; the epineurium of one of the nerve section is pulled over the nerve end of the other nerve section and welded with 3 to 5 laser pulses followed by welding of the entire circumference with 10 to 15 laser pulses (**1a**). **Laser assisted nerve repair in combination with chromophore and/or solder; 1a** followed by applying the chromophore and/or solder on the repair site and welding of the chromophore and/or solder and the epineurium with 10 to 15 laser pulses (**1b**).

As a control group (group IV, n = 6), the nerves were repaired by conventional microsurgical suture repair (CSMR) with four peri/epineurial 10-0 nylon sutures (10-0 Dermalon black monofilament, Davis-Geck, UK). Summary of the experimental groups is given in Table 1.

Table 1. Summary of the experimental set-up

Group	Repair technique	n
I	CO_2 laser	6
	Nd:YAG laser	6
II	Nd:YAG laser + blood	6
III	CO_2 laser + albumin[1]	6
	Nd:YAG laser + blood + albumin[1]	6
IV	CMSR[2], 4 peri/epineurial nylon sutures	4

[1] albumin powder dissolved in saline
[2] CMSR - conventional microsurgical suture repair

Table 2. The laser settings and the macroscopic changes of nerve repair using different lasers and techniques

Laser and technique	Power (W)	Time per pulse (s)	Macroscopic changes
CO_2 laser	0.10	1	shrinkage/whitening
CO_2 laser + albumin	0.10	1	brown discoloration
Nd:YAG laser	12	1	shrinkage/whitening
Nd:YAG laser + blood	1	3	browning/charring
Nd:YAG laser + blood + albumin	1	3	browning

In all groups, each repair site was observed meticulously with a 40 fold magnification after the welding procedure, and the visible effects of laser radiation on the epineurium were classified. The laser parameters for each laser and technique are shown in Table 2. These laser settings have shown in pilot studies to produce the strongest welds (21). The CO_2 laser was used in conjunction with an operating microscope (OpMi-1, Zeiss Inc., West Germany) and a joystick micromanipulator, with a 320 µm spot size. For the Nd:YAG laser, the laser energy was applied using a 600 µm optical fiber with a bare tip, held at a fixed distance from the tissue (2 mm). All lasers were operated in a continuous wave mode (CW) and the pulse duration was either controlled by an internal or an external electrical shutter (T 132, Optilas Inc., The Netherlands).

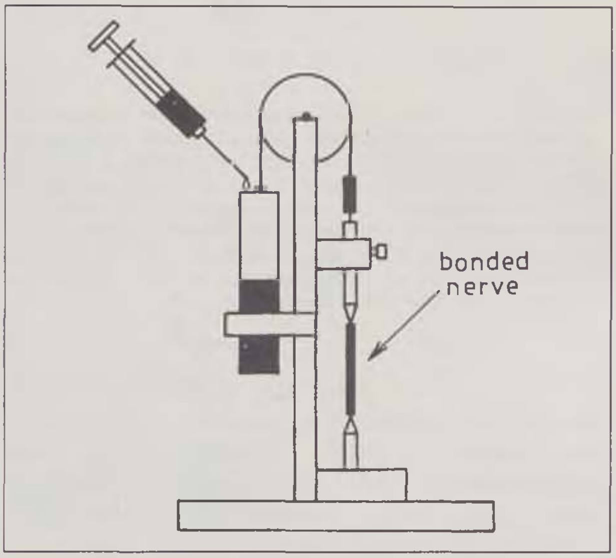

Fig. 2. Schematic view of the weighing system. In each measurement, the container was filled with water until the weight caused dehiscence of the union.

The relative bonding strength of the nerves was measured directly after the repair using a gradual weighing system. The distal end of the nerve was fixed with a clamp, while the proximal and was attached to a plastic container through a fixed pulley mechanism (Fig. 2). If the container was empty, the system was in equilibrium. The container was filled with water until the weight caused dehiscence of the nerve ends. The rate of water flow into the container was constant for all experiments (16.4 ml/min) using a small needle (25 G). The bonding strength was defined as the weight of water (in g) that caused dehiscence of the nerve ends. The bonding strength was measured by measuring the weight of the container, partially filled with water, with a balance (AJ 50, Mettler Inc., The Netherlands), and by subtracting the weight of the empty container. The data were statistically analyzed using a non-parametric Mann-Whitney U test since the samples were not established as coming from a normal distribution.

Thermal Damage Study

To study the thermal damage to the nerve following irradiation with the different lasers and chromophores/solders, circumferential irradiation of the nerve was performed with the same manner and laser settings as in the group I, II, and III, except that the nerves were not transsected. This was done because transsection itself causes degeneration of the nerve which jeopardize the assesment of the nerve damage resulting from laser irradiation. After irradiation, the wound bed was rinsed with saline, the fascia of the hamstring muscles were closed with 6-0 nylon sutures, and the skin was closed with Dexon 4-0 absorbable sutures. For each laser and technique, six irradiation were performed. All surgical procedures were carried out by the same person.

The motor function of the nerves in the postoperative period was examined daily using a modified version of the „toe-spreading test" (9, 29). In short, the toe-spreading, defined as the distance from the first to the fifth digit, from both hind legs was measured from walking tracts. The relative toe-spreading of the right foot was calculated with the untreated left foot as a control. A 100% motor function loss will result in a relative toe-spreading of 30 %, while no motor function loss will result in a relative toe-spreading of 100 %. For each measurement, at least 4 foot steps were recorded.

The rats were killed one day (n = 3) and 7 days (n = 3) after surgery by an overdose Nembutal intraperitoneally and the nerves were carefully dissected. Half of the nerves were fixed in 10% buffered formaline, embedded in paraffin, sectioned (4 µm) and stained with Masson trichrome, Bodian, and hematoxylin and eosin for neuropathological examination. The other half of the nerves was fixed in Karnovsky fixative, postfixed in osmium tetroxide 1% (OsO_4), stained with uranyl acetate, dehydrated in acidified 2,2-dimethoxypropane (DMP), and embedded in Epon. After hardening, thin sections were cut (1.25 µm), and stained with toluidine blue and basic fuschine.

RESULTS

Bonding Strength Study

In all nerves, there was evidence of adequate tissue bonding. Figure 3 gives an overview of the bonding strength of the different methods of nerve repair. The weakest laser welds were performed with the CO_2 laser (bonding strength 2.12 ± 1.23 g). The bonding strength of the Nd:YAG laser alone (3.9 ± 2.2 g) and with addition of blood (5.3 ± 2.1 g) was slightly higher, however, statistically not different from the bonding strength of the CO_2 laser alone ($p > 0.01$). The bonding strength of CO_2 laser repair in combination with

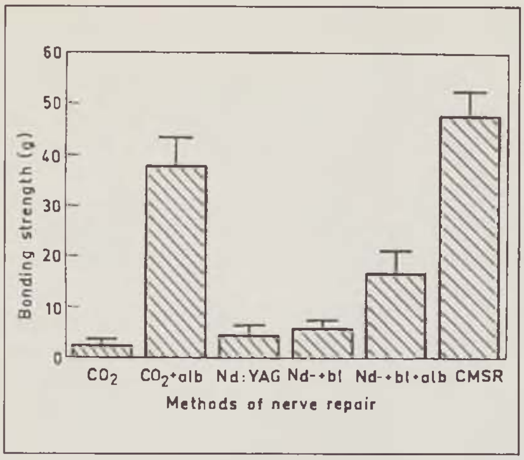

Fig. 3. Average bonding strength (± s.d.) of nerve repairs achieved by different methods. CO_2 + alb = CO_2 laser with albumin: Nd⁻ + bl = Nd:YAG laser with blood; Nd⁻ + b1 + alb = Nd:YAG laser with blood and albumin; CMSR = conventional microsurgical suture repair.

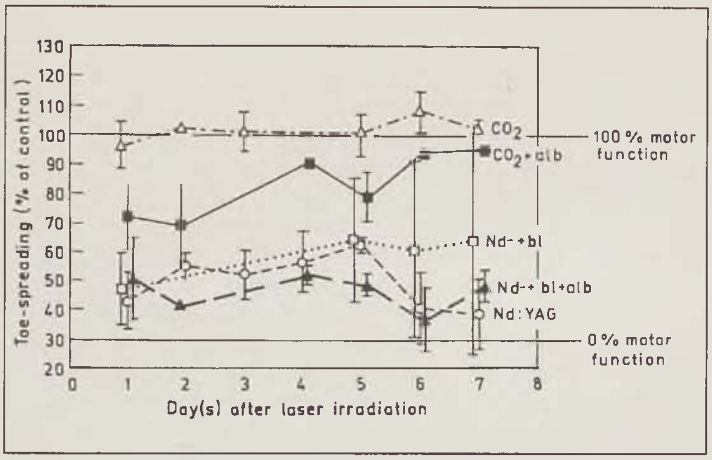

Fig. 4. Toe-spreading of the hind paws of rats after irradiation with the CO_2 and the Nd:YAG laser vs. day(s) after laser irradiation. Each point represent the mean ± standard error. CO_2 + a1b = CO_2 laser with albumin, Nd⁻ + b1 = Nd:YAG laser with blood, Nd⁻ + b1 + a1b = Nd:YAG laser with blood and albumin.

albumin (37.33 ± 6.06 g) was higher than those of any other laser techniques and did not differ statistically from CMSR (47.6 ± 5.1 g) ($p > 0.01$). The Nd:YAG laser in combination with blood and albumin (16.3 ± 4.8 g) produced significant stronger welds than Nd:YAG laser alone or with addition of blood (5.3 ± 2.1 g) ($p > 0.01$).

Observation of the nerve during CO_2 and Nd:YAG laser irradiation showed whitening and in some case slight brown discoloration and some degree of shrinkage of the irradiated area. In the CO_2 laser and solder group, the solder showed drying, slight brown discoloration, and adherence to the nerve without excessive macroscopic changes of the nerve itself. The Nd:YAG laser repaired nerves using blood as chromophore demonstrated browning and charring (carbonization) of the irradiated area.

Table 2 gives an overview of the macroscopic changes at the surface after laser irradiation.

Thermal Damage Study

All rats did well postoperatively and had no signs of infection or neurological complications except for variable dysfunction of the right sciatic nerve as described bellow.

Toe-spreading test showed no changes in nerve function irradiated with the CO_2 laser alone. In the CO_2 laser and solder group, there was a moderate decrease in nerve function, but this decrease in function was transient and disappeared by day six after irradiation. In the Nd:YAG laser groups, there was a significant loss of nerve function for all Nd:YAG laser groups up to 90 %. Figure 4 shows the relative toe-spreading for all laser groups vs. time after laser irradiation.

Histologically, several pathological reactions ranging from minimal changes to total destruction of the nerve were observed, strongly related to the type of the laser and the repair technique. Using the CO_2 laser alone, the thermal damage to the nerve was solely confined to the subperineurial axons. The pathological changes consisted of two relatively thin layers. In the outer zone (ca 75 µm), located directly subperineurially, the nerve tissue was oedematous and the nerve fibres had darkly stained cytoplasm. The second zone (ca 50 µm), located more towards the centre, was also oedematous but the myelin sheaths were thin and separate layers on myelin sheaths were intruding in the axoplasm. Also, enlarged and empty endoneurial tubules were seen. Both the inner and outer zone was undergoing Wallerian degeneration. Very few inflammatory changes were noted. The vessels in the epineurium and vessels located in the injured area were thrombosed and the perivascular space was enlarged. No haemorrhagic lesions could be observed. The epineurium was oedematous and the fibroblasts showed dark picnotic nuclei. The morphological integrity of the epi- and perineurium was not affected. The extent of the total thermal damage was approximately 125 µm. The central part of the nerve was undamaged. Around the patent blood vessels in the injured area, a few myelinated axons appeared to be intact.

In the CO_2 soldered nerves, the solder was identified as a homogenous material surrounded and infiltrated by inflammatory cells with a large amount of polymorphonuclear leukocytes. The intraneural changes were similar to the non-soldered nerves, although the extent of thermal damage was slightly more. At day one, morphological changes proximal or distal from the irradiated area were not seen.

The most severe reaction, occurring with the use of the Nd:YAG laser, consisted of total destruction of the epi- and perineurium and the subperineurial axons. In this area, the tissue structure was hardly recognisable. More towards the centre of the nerve, massive Wallerian degeneration with endoneurial oedema was observed. In this region, the blood vessels were thrombosed and the injured axons were retracted away from their myelin sheaths and Schwann cells. Several inflammatory cells were observed.

At week one, some minor adhesions were found in CO_2 irradiated nerves while moderate adhesions of the nerve to the tissue were observed in the CO_2 soldered nerves. Degeneration of axons and myelin sheaths (Wallerian degeneration), both at the site of irradiation and in the distal nerve segment was noted only in the subperineurial area with a depth of approximately 100 μm. Within this area, cellular reaction consisting of presence of macrophages, lymphocytes, and proliferating Schwann cells was noted. Remnants of myelin were found in Schwann cells and macrophages. The epineurium and perineurium was thickened (due to oedema and collagen production), and the epineurium was characterised by a generalised cell infiltrate and dilated vessels. However, the morphological integrity of the epi- and perineurium was not affected. The blood vessels within the nerve appeared normal. In the epineurium, an increase in normal collagen with active young fibroblasts was noted. In the CO_2 soldered nerves, the degenerative changes within the nerve were the same. A lot of inflammatory cells and macrophages could be seen within the epineurium surrounding small remnants of the solder. The extent of the termal damage was comparable to non-soldered nerves.

The Nd:YAG laser irradiated nerves showed massal Wallerian degeneration with numerous inflammatory cells and macrophages. These changes were also noted distally to the irradiated area.

DISCUSSION

Laser-assisted nerve repair has certain (theoretical) advantages over sutured repairs, such as less traumatic nerve handling, avoidance of a foreign body reaction, a watertight seal of the epineurium, and a reduced operation time. The application of laser energy to repair nerves is an intriguing one, but as yet, unproved modality. Various experimental studies have revealed promising results (2, 3, 7, 11, 12, 15, 16, 26), but widespread use has of tissue welding been hindered by technical obstacles and inability to achieve consistent results. Whereas most studies on tissue welding have been devoted to arteries, little work has been done to investigate laser-assisted repair of nerves. Fundamental studies are sparse, comparative studies between different lasers and techniques are lacking, and information is missing about the thermal damage following laser irradiation on peripheral nerve tissue. In a previous study, we have determined the optimal laser parameters and techniques for CO_2 laser-assisted nerve repair in an *in vitro* study (21). Before undertaking an *in vivo* repair experiments, it is essential to gain more knowledge on the tensile strength of laser bonded nerves and the subsequent thermal damage. In this study, we have selected the most common laser used in the clinical setting, i.e. the CO_2 and the Nd:YAG laser, as both have been proposed and successfully used for microsurgical repair of various tissues.

There are only few studies reporting on the acute bonding strength of CO_2 laser welded nerves, while on the Nd:YAG laser there are no data available. Maragh et al. (17) reported that CO_2 LANR had a strength of 43.1 g at day 4 postoperatively. At day 8, LANR had a strength comparable to the epineurial suture control group (166.7 g). Thumfart (28) studied the bonding strength of CO_2 LANR, LANR + fibrin glue, and suture repairs *in vitro*. No bonding could be achieved in the LANR group, and LANR + fibrin glue provided weaker bonding strengths than fibrin glue repair alone. Menovsky et al. (21) reported a maximal strength of 2.4 g *in vitro* under optimal CO_2 laser settings.

In this study, the bonding strength of CO_2 laser repairs was lowest of any other laser repair. However, comparison with the Nd:YAG laser repairs, both without and with blood as chromophore showed no statistical difference. The strongest laser welds were performed with the CO_2 laser in combination with albumin as a solder, which is comparable with CMSR. The Nd:YAG laser repairs with the use of blood and albumin were stronger than with blood alone, but still lower than the CO_2 laser in combination with albumin. Although the power used for the Nd:YAG laser was quit high (12 W), we were not successfull in achieving repairs with lower powers. Using blood as a chromophore, the power required for tissue fusion could be minimized to 1 W. However, even these low powers resulted in a significant damage to the nerve.

In the second part of the study, thermal damage and nerve function of peripheral nerves irradiated with a CO_2 and Nd:YAG laser were investigated. A survival time of 1 and 7 days was chosen because the thermal damage to biological tissue is assumed to be complete (27). Since the second part of this study focused on thermal damage and function, the nerves were not transected prior to laser irradiation (transection normally would be performed prior to nerve repair). Reactions resulting from the traumatic division only would have hampered the assessment of the tissue reaction caused by laser irradiation.

Due to the shallow tissue penetration at 10,600 nm, it is expected that the CO_2 laser energy is mostly absorbed at the tissue surface, and in combination with short pulse durations, would result in minimal damage within the substance of the nerve. Richmond reports no histological, behavioral or neurologic deficits following CO_2 laser irradiation of intract rat sciatic nerves at a power of 70-80 mW and pulse durations of several microseconds (24). Myers et al. (22) did find thermal damage in rat sciatic nerve irradiated with a CO_2 laser at relatively high power for tissue welding of 5 W during 0.25 s and 0.5 s, using a relatively large sport size of 2 mm. Wallerian degeneration and perivascular and subperineurial oedema marked the nerve injury two days after irradiation. In this study, the pathological changes of the nerve tissue consisted of a small zone of subepineurial Wallerian degeneration with edema, swelling of vascular structures, damaged endothelial cells and vascular occlusion, while the central part of the nerve remained undamaged. Motor function as assessed by toespreading test showed no deficit. When using the CO_2 laser in combination with a solder, the thermal damage and loss of motor function was sligthly more. The difference between the tissue damage and function loss between the both CO_2 laser groups can be explained by the fact that the soldered nerves required a greater amount of laser pulses to coagulate the soldernerve complex than welding with CO_2 alone, resulting in heat accumulation. All nerves irradiated with the Nd:YAG laser showed massive destruction of both neural and connective tissue. This can be explained by the fact that the Nd:YAG laser emits most of its energy in the near-infrared portion of the spectrum at 1,064 nm. The Nd:YAG wavelength is poorly absorbed by water and absorption in blood is moderate. However, there is virtually no enhanced absorption for any of the tissue chromophores. Thus, in most of the tissues the Nd:YAG laser has a penetration depth of approximately 3-9 mm. As a consequence, in the case of the rat sciatic nerve, the whole circumference of the nerve is „coagulated" by the Nd:YAG laser. This correlates well with the observed loss of motor function. The large standard deviations for almost all groups of laser repair can be explained by the fact that relatively small amount of animals were used per group.

In conclusion, this study has compared two surgical lasers and techniques to perform microsurgical repair of transected sciatic nerves in a rat model. With respect to the acute tensile strength and thermal damage, the CO_2 laser in combination with albumin produces the strongest repairs (comparable to to sutured nerve repairs) with the least thermal damage. These results encourage further *in vivo* research using the CO_2 laser and albumin solder. Based on the results presented, the Nd:YAG laser can be abandoned from the list of surgical lasers suited for peripheral nerve repair.

REFERENCES

1. Alefelder, J., Philipp, J., Engelmann, UH., Senge, T. Stendted laser-welded vasovasostomy in the rat: comparison of Nd:YAG and CO_2 lasers. *J. Reconstr. Microsurg.*, 7: 317-320, 1991.

2. Almquist, EE., Nachemson, A., Auth, D., Almquist, B., Hall, S. Evaluation of the use of the argon laser in repairing rat and primate nerves. *J. Hand. Surg. Am.*, 9: 792-799, 1984.

3. Bailes, JE., Cozzens, JW., Hudson, AR., Kline, DG., Ciric, I., Gianaris, P., Bernstein, LP., Hunter, D. Laser-assisted nerve repair in primates. *J. Neurosurg.*, 71: 266-272, 1989.

4. Benke, TA., Clark, JW., Wisoff, PJ., Schneider, S., Balasubramaniam, C., Hawkins, HK., Laurent, J., Perling, L., Shehab, A. Comparative study of suture and laser-assisted anastomoses in rat sciatic nerves. *Lasers Surg. Med.*, 9: 602-615, 1989.

5. Burger, RA., Gerharz, CD., Draws, J., Englemann, UH., Hohenfellner, R. Sutureless laser-welded anastomosis of the femoral artery and vein in rats using CO_2 and Nd:YAG lasers. *J. Reconstr. Microsurg.*, 9: 213-218, 1993.

6. Burger, RA., Gerzharz, CD., Rothe, H., Engelmann, UH., Hohenfellner, R. CO_2 and Nd:YAG laser systems in microsurgical venous anastomosees. *Urol. Res.*, 19: 253-257, 1991.

7. Campion, ER., Bynum, DK., Powers, SK. Repair of peripheral nerves with the argon laser. A functional and histological evaluation. *J. Bone Joint. Surg. Am.*, 72: 715-723, 1990.

8. Cikrit, DF., Dalsing, MC., Weinstein, TS., Palmer, K., Lalka, SG., Unthank, JL. CO_2-welded venous anastomosis: enhancement of weld strength with heterologous fibrin glue. *Lasers Surg. Med.*, 10: 584-590, 1990.

9. de Medinaceli, L., Freed, WJ., Wyatt, RJ. An index of the functional condition of rat sciatic nerve based on measurements made from walking tracts. *Exp. Neurol.*, 94: 788-790, 1982.

10. Dubuisson, AS., Kline, DG. Is laser repair effective for secondary repair of a focal lesion in continuity? *Microsurgery*, 14: 398-401, 1993.

11. Eppley, BL., Kalenderian, E., Winkelmann, T., Delfino, JJ. Facial nerve graft repair: suture versus laser-assisted anastomosis. *Int. J. Oral. Maxillofac. Surg.*, 18: 50-54, 1989.

12. Fischer, DW., Beggs, JL., Kenshalo, DLJ., Shetter, AG. Comparative study of microepineurial anastomoses with the use of CO_2 laser and suture techniques in rat sciatic nerves: Part 1. Surgical technique, nerve action potentials, and morphological studies. *Neurosurgery*, 17: 300-308, 1985.

13. Huang, TC., Blanks, RH., Berns, MW., Crumley, RL. Laser vs. suture nerve anastomosis. *Otolaryngol. Head Neck Surg.*, 107: 14-20, 1992.

14. Kim, DH., Kline, DG. Peri-epineurial tissue to supplement laser welding of nerve. *Neurosurgery*, 26: 211-216, 1990.

15. Korff, M., Bent, SW., Havig, MT., Schwaber, MK., Ossoff, RH., Zealear, DL. An investigation of the potential for laser nerve welding. *Otolaryngol. Head Neck Surg.*, 106: 345-350, 1992.

16. Lal, AP., Joseph, T., Chandi, SM., Pant, B. Facial neurorrhaphy with autologous sural nerve graft using the CO_2 laser in a primate model. *Neurosurgery*, 32: 1011-1014, 1993.

17. Maragh, H., Hawn, RS., Gould, JD., Terzis, JK. Is laser nerve repair comparable to microsuture coaptation? *J. Reconstr. Microsurg.*, 4: 189-195, 1988.

18. Menovsky, T. Modified surgical approach of the rat sciatic nerve. *Microsurgery*, 16: 510-511, 1995.

19. Menovsky, T. *Laser-assisted nerve repair. An experimental study.* Academic Thesis, University of Amsterdam, 1999.

20. Menovsky, T., Beek, JF., Thomsen, SL. Laser(-assisted) nerve repair. A review. *Neurosurg. Rev.*, 18: 225-235, 1995.

21. Menovsky, T., Beek, JF., van Gemert, MJ. CO_2 laser nerve welding: optimal laser parameters and the use of solders in vitro. *Microsurgery*, 15: 44-51, 1994.

22. Myers, RR., James, HE., Powell, HC. Laser injury of peripheral nerve: a model for focal endoneurial damage. *J. Neurol. Neurosurg. Psychiatr.*, 48: 1265-1268, 1985.

23. Poppas, DP., Rooke, CT., Schlossberg, SM. Optimal parameters for CO_2 laser reconstruction of urethral tissue using a protein solder. *J. Urol.*, 148: 220-224, 1992.

24. Richmond, IL. The use of lasers in nerve repair. In: Fassano, VA. (Ed.). *Advanced intraoperative technologies in neurosurgery*. New York : Springer Verlag, pp. 175-183, 1986.

25. Schober, R., Ulrich, F., Sander, T., Durselen, H., Hessel, S. Laser-induced alteration of collagen substructure allows microsurgical tissue welding. *Science,* 232: 1421-1422, 1986.

26. Seifert, V., Stolke, D. Laser-assisted reconstruction of the oculomotor nerve: experimental study on the feasibility of cranial nerve repair. *Neurosurgery,* 25: 579-582, 1989.

27. Thomsen, S. Laser-tissue interaction. *J. Photochem. Photobiol.,* 1: 1-2, 1990.

28. Thumfart, WF., Gunkel, A., Ollwig, M. Comparative studies of the stability of nerve anastomoses using CO_2 laser adaptation compared with conventional technics. HNO, 38: 184-187, 1990.

29. Wondergem, J., Haveman, J., Rusman, V., Sminia, P., van Dijk, JDP. Effects of local hyperthermia on the motor function of the rat sciatic nerve. *Int. J. Radiat. Biol.,* 3: 429-438, 1988.

Address for correspondence:

Tomas Menovsky, M.D., Ph.D.,
Department of Neurosurgery,
University Hospital Nijmegen St Radboud,
P.O. Box 9101,
6500 HB Nijmegen,
The Netherlands

CLEFT PALATE REPAIR BY FURLOW DOUBLE-REVERSING Z-PLASTY: FIRST SPEECH RESULTS AT THE AGE OF 6 YEARS

Vokurková J.[1], *Mrázek T.*[1], *Výška T.*[1], *Pešlová M.*[2], *Veselý J.*[1]

[1] Department of Plastic and Aesthetic Surgery, St. Ann Hospital, School of Medicine, Masaryk University, Brno, Czech Republic
[2] Department of Phoniatrics, St. Ann Hospital, Brno, Czech Republic

SUMMARY

The authors evaluated the first 15 six-year-old children operated on for cleft palate using double-reversing Z-plasty. Examination by a surgeon did not reveal a higher morbidity as a results of the new surgical method. Examination by a phoniatrist provided evidence of marked improvement of speech functions as compared with the previous von Langenbeck method. The results are preliminary, based on a small group of patients.

ZUSAMMENFASSUNG

Die Operation der Gaumenspalte mithilfe der reversen Doppel-Zetplastik: Die erste Auswertung der Sprechergebnissen im Alter von 6 Jahren

Vokurková J., Mrázek T., Výška T., Pešlová M., Veselý J.

Es wurde ausgewertet die Gruppe der ersten 15 sechsjährigen Kinder, die sich der Operation der Gaumenspalte mithilfe der reversen Doppel-Zetplastik unterzogen. Die Untersuchung durch den Chirurgen erwies keine erhöhte Morbidität, die durch die Einführung der neuen Operationsmethode verursacht werden könnte. Die Untersuchung durch den Phoniater erwies eine bedeutende Verbesserung der Sprechfunktionen im Vergleich zu der vorherigen Methode nach von Langenback. Die Ergebnisse sind vorläufig und durchgeführt an einer kleinen Gruppe von Patienten.

Key words: cleft palate, Furlow palatoplasty, surgery, speech assessment

Since the first presentation of a new method of soft palate surgery by Dr. Leonard Furlow at the meeting of the Southeastern Society of Plastic Surgery in Boca Raton, Florida, in spring 1978 (Randall, 1986), many short-term and long-term results have been published (Furlow, 1986; LaRossa, 1990; Vistnes, 1990; Horsewell, 1993; Kuo-Ting Chen, 1993; Senders, 1995; Lin, 1999). Furlow's elegant solution of the problem of muscle disorientation (La Rossa, 1990) has been fully accepted by many cleft surgeons, however, by others it is still refuted even today.

At the Clinic of Plastic and Aesthetic Surgery in Brno, treatment of patients with clefts has a 50-year tradition. In the eighties the most frequently used method for suture of the palate was a modification of von Langenbeck's method without directed reorientation of the muscles of the soft palate. In 1985 (Bařinka, 1990) the timing of the operations changed from the age of 3 years to the age of 12-18 months. The method was preserved. In the nineties suture of the palate was performed at the age of 9-12 months, if the child was in good health. However, the surgical procedures changed. In 1992 von Langenbeck's method was modified by intravelar veloplasty (Kriens, 1969) and eventually replaced by the method of two-flap palatoplasty with intravelar veloplasty (Bardach, 1990), still currently used. In 1993 the authors started to operate using the method of double-reversing Z-plasty in patients with a narrow palatine cleft. Furlow's palatoplasty was, in subsequent years, also used in wider clefts, and during the last four years approximately half the patients with clefts were operated on by double-reversing Z-plasty and half by two-flap palatoplasty. Since 1992 there has been a team of three surgeons highly competent in the problem of clefts.

Every year some 55-62 children with a primary cleft palate undergo surgery, operated incl. two thirds with an isolated cleft palate and one third with a complete cleft. Five to the children are operated due to a submucous cleft and in some 15 patients operated on by earlier techniques, reoperation of the palate by Furlow's method is performed.

Surgical treatment is followed by monitoring and treatment by a phoniatrist and orthodontist. The speech pathologist has long-term training in the problems of clefts and exemins speech development every 6 months. When the child has reached an age between two and three, the speech pathologist recommends logopedic therapy at the child's home.

PATIENTS AND METHODS

Selection of Patients

Retrospectively, seventeen 6-year-old children who underwent surgery for non-syndromic cleft palate, or a cleft palate in combination with a cleft lip (unilateral) were examined. The surgical method for closure of the palate was Furlow's double-reversing Z-plasty. The operations were performed by three equally trained surgeons at the Clinic of Plastic and Aesthetic Surgery in Brno in 1993 and 1994.

Two children were eliminated from the group because of low intellect; the remaining 15 children were in good health. All children were followed up once or twice a year by the operating surgeon, a phoniatrist and an orthodontist.

Demography of the Patients

Ten girls (67 %) and 5 boys (23 %), mean age 12.3 months (9-14 months) were operated on. Two patients had a complete unilateral cleft (suture of the lip at the age of 3 months) and 13 patients had an isolated cleft palate, incl. 7 who had an isolated cleft of the soft palate. All patients had a narrow cleft (under 1 cm).

Surgical Technique

The method described by Furlow (1986) was used in Randall's (1990) partial modification, which included designing the flap with a wider angle to the cleft margin and using relaxing incisions but without fracturing the hook of the hamulus bone (Figs 1, 2). All three surgeons are right-handed, so the posteriorly based oral mucomuscular flap was placed on the patient's left side.

Fig. 1. Cleft of the soft palate before operation according to Furlow at 13 months of age.

Fig. 2. Velum of the 6-year-old patient after operation according to Furlow.

Follow-up

1. The surgeon followed the healing of the palate and possible complications, maturing of the scar, long-term complications - fistulas, velopharyngeal insufficiency (VPI) and speech development.
2. The phoniatrist performed examinations of speech and hearing in all children:
   (a) speech according to Brohm: 4 - vowel speech,
   3 - some consonants are correctly pronounced,
   2 - incorrect pronounciation of hissing sounds and R, Ř persists,
   1b - fair speech; correct pronounciation of 1 or 2 consonants lacking or not fixed,
   1a - quite correct speech;
   (b) Gutzmann's test A-I to assess hyperrhinophonia.
3. Comparison of this group of children with two groups of 6-year-olds examined by the same phoniatrist and operated on at the Clinic of Plastic Surgery in Brno by the von Langenbeck method at the age of 1 or 3 years (Kuthanová, 1994).

RESULTS

1. In the group of 15 patients one postoperative complication developed - prolonged haemorrhage treated by medication without surgical intervention. None of the patients had a pre- or postoperative blood transfusion. In three patients the oral mucosal flap desquamated with satisfactory healing of the nasal mucosa; healing was protracted by a week due to spontaneous epithelization. None of the patients developed a fistula.

In five patients healing occurred by a hypertrophic scar (two patients with prolonged oral healing), which receded after massage of the palate.

The follow-up of speech development was consistent with the examination by a phoniatrist. VPI of a mild degree was observed at the age of 4 years in four patients (26.6 %); at the age of 6 years it persisted in one patient (6.6 %).

2. The examination by a phoniatrist using Brohm's test with marks 1a-4 is illustrated in Fig. 3. None of the children had a mark of 3 or 4 at the age of 6 years, i.e. vowel speech or poor pronounciation of some consonants. Speech with poor pronounciation of hissing sounds and R, Ř (difficult in Czech) was observed in 20 % of the children, correct pronounciation except for one or two consonants (evaluated as mark 1b) was found in 53 %, and 27 % children had faultless speech (mark 1a).

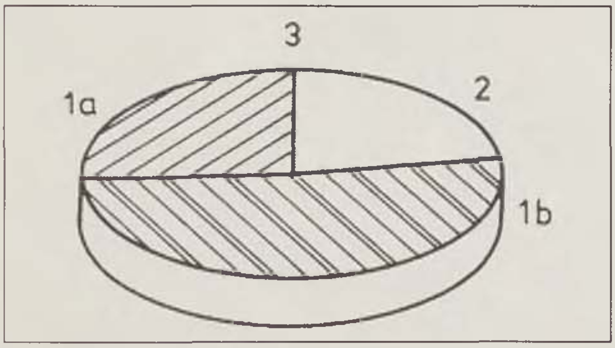

Fig. 3. Speech results according Brohm of 6-year-old patients in percentage: palatoplasty at 1 year of age, Furlow's method.

Hyperrhinophonia examined by Gutzmann's test A-I was seen in one boy (6.6 %), consistent with the surgeon's examination.

3. For comparison of speech the work of Kuthanová (1994) was used, in which the same phoniatrist and the same tests were used to examine six-year-old children, operated on at the age of 3 or 1 year by von Langenbeck's method without directed reorientation of the soft palate muscles. Children operated on at the age of one year (Fig. 4) have markedly better speech than those operated on at the age of 3 years (Fig. 5). A marked improvement after reconstruction of the palate by double reversing Z-plasty is apparent from the comparative table (Tab. 1).

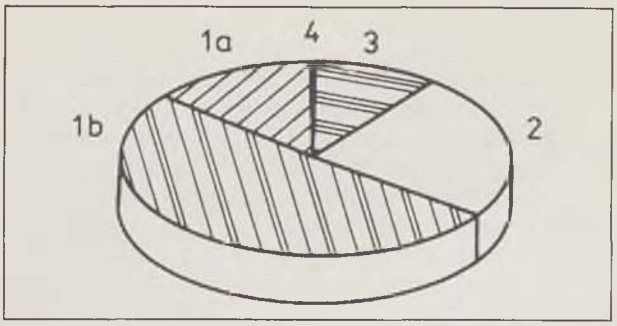

Fig. 4. Speech results according Brohm of 6-year-old patients in percentage: palatoplasty at 1 year of age, von Langenbeck's method.

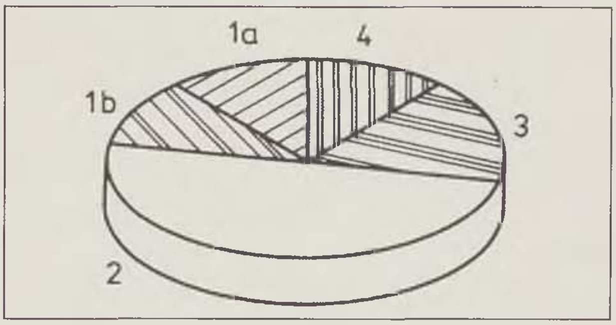

Fig. 5. Speech results according Brohm of 6-year-old patients in percentage: palatoplasty at 3 years of age, von Langenbeck's method.

Table 1. Comparison of speech results according Brohm of 6-year-old patients

Brohm	von Langenbeck at 3 years (%)	von Langenbeck at 1 year (%)	Furlow at 1 year (%)
4	6,6	0	0
3	25	6	0
2	48,7	33,7	20
1b	13,1	51,3	53
1a	6,6	9	27

DISCUSSION

Examination of the first children following cleft palate repair using Furlow's technique revealed very good results as regards speech. We are, however, aware of the great subjectivity of these results. A small group of patients was examined, children with a narrow cleft and patients with an isolated cleft of the soft palate, in whom better functional results can be expected in general. A relatively subjective examination method was used, though by a single skilled doctor under standard conditions.

As we currently use Furlow's method in about half of the patients with all types of clefts, and in the other half we use intravelar veloplasty, a comparative study of these two surgical approaches is underway in our department. Here we are presenting our first report with the encouraging results of our study. In the group of the by-now four-year-old patients, the majority completed logopedic care and have faultless speech. Some children are only followed-up by a phoniatrist and because of quite adequate speech development and proper velopharyngeal closure need not visit a speech therapist.

By the introduction of new techniques in cleft palate surgery, speech development improved markedly as compared with previous methods. The results are so far preliminary and results from larger groups of patients are needed.

REFERENCES

1. Bardach, J., Salyer, K. *Surgical Techniques in Cleft Lip and Palate.* St. Louis : Mosby-Year book, 1991.
2. Brothers, D., Dalston, R., Peterson, H., Lawrence, T. Comparison of the Furlow Double-Opposing Z-Palatoplasty with the Wardill-Kilner Procedure for Isolated Clefts of the Soft Palate. *Plast. Reconstr. Surg.*, 95: 969-976, 1995.
3. Furlow, L. Cleft Palate Repair by Double Opposing Z-Plasty. *Plast. Reconstr. Surg.*, 78: 724-738, 1986.
4. Horswell, B., Castiglione, Ch., Poole, A., Assael, L. The Double-Reversing Z-Plasty in Primary Palatoplasty: Operative Experience and Early Results. *J. Oral Maxillofac. Surg.*, 51: 145-149, 1993.
5. Chen, P., Wu, J., Chen, Y., Noordhoff, MS. Correction of Secondary Velopharyngeal Insufficiency in Cleft Palate Patients with the Furlow Palatoplasty. *Plast. Reconstr. Surg.*, 94: 933-941, 1994.
6. Kriens, O. An Anatomical Approach to Veloplasty. *Plast. Reconstr. Surg. J.*, 43: 39-41, 1969.
7. Kuderová, J., Borský, J., Černý, M., Müllerová, Ž., Vohradník, M., Hrivnáková, J. Care of Patients with Facial Clefts at the Department of Plastic Surgery in Prague. *Acta Chir. Plast.*, 38: 99-103, 1996.
8. Kuehn, D., Folkins, J., Linville, R. An Electromyographic Study of the Musculus Uvulae. *Cleft Palate Craniofac. J.*, 25: 348-355, 1988.
9. Kuthanová, B. *Palatolálie*. Brno : PFMU, 1994.
10. LaRossa, D. The Furlow Double Reversing Z-Plasty for Cleft Palate Repair: The First Years of Experience. In Bardach, J., Morris, HL. (Eds.) *Multidisciplinary Management of Cleft Lip and Palate.* Philadelphia : W. B. Saunders, 1990, pp. 337-340.
11. Lin, K., Goldberg, D., Williams, Ch., Borowitz, K., Persing, J., Edgerton, M. Long-Term Outcome Analysis of Two Treatment Methods for Cleft Palate: Combined Levator Retropositioning and Pharyngeal Flap Versus Double-Opposing Z-Plasty. *Cleft Palate Craniofac. J.*, 36: 73-78, 1999.
12. Randal, P., LaRossa, D. Cleft Palate. In McCarthy, JG. (Ed.) *Plastic Surgery*. Philadelphia : W. B. Sounders, 1990, pp. 2739-2742.
13. Randall, P., LaRossa, D., Solomon, M., Cohen, M. Experience with the Furlow Double-Reversing Z-Plasty for Cleft Palate Repair. *Plast. Reconstr. Surg.*, 77: 569-574, 1986.
14. Senders, C., Sykes, J. Modifications of the Furlow Palatoplasty (Six- and Seven-Flap Palatoplasties). *Arch. Otolaryngol. Head Neck Surg.*, 121: 1101-1104, 1995.
15. Sovák, M. *Logopedie předškolního věku.* Praha : SNP, 1984.
16. Vistnes, L., Jobe, R. Experience with the Furlow Palatoplasty. In Kernahan, DA., Rosenstein, SW. *Cleft Lip and Palate. A System of Management.* Baltimore : Williams & Wilkins, 1990, pp. 199-203.

Address for correspondence:

J. Vokurková
Department of Plastic and Aesthetic Surgery
Berkova 34
612 00 Brno
Czech Republic

ACTA CHIRURGIAE PLASTICAE 42, 1, 2000, pp. 27 - 36

ANALYSIS OF INTRACRANIAL RELATIONS IN PATIENTS WITH UNILATERAL CLEFT LIP AND PALATE USING CLUSTER AND FACTOR ANALYSIS

Velemínská J.

Department of Anthropology and Human Genetics, Charles University, Faculty of Natural Sciences, Prague, Czech Republic

SUMMARY

The present investigation was based on the cephalometric analysis of lateral teleroentgenographic pictures of 48 ten-year-old boys with complete unilateral clefts of the lip and palate. Using cluster and factor analysis, the author investigated the relationships among 75 craniofacial size, shape and position characteristics. Both multivariation methods proved useful in the search for associations between partial cranial structures. They supplemented each other well, and their combined use contributed to the definition of the following basic and specific principles of craniofacial relations and compensatory and adaptive mechanisms in patients with clefts. The maxilla consists of two mutually almost independent parts. The vertical parameters of the anterior upper face are interrelated with the slope of the palate plane; the dentoalveolar component of the upper jaw is formed independently. This fact can be aptly explained by the effect of orthodontic treatment, which contributes substantially to an improvement of the facial configuration. Rotation of the mandible has an impact on the vertical dimensions of the anterior lower, as well as the whole, face and is closely associated with the position of the mandibular body but not with the position of its branch nor with its length. The slope of the mandibular branch correlates with the mental angle, with the gonial angle and the slope of its dentoalveolar component, which is the result of adaptation to a shortening of the maxilla while preserving a positive overjet. Damage to the sagittal intermaxillary and interalveolar relations is primarily due to a reduction in the depth of the maxilla and is associated with the length of the mandibular body, while no relation with its rotation or length of the ramus was found. Solution of the given problem may help to find predictive models of facial development in patients with clefts.

ZUSAMMENFASSUNG

Die Analyse der intrakranialen Beziehungen bei Patienten mit der einseitigen Gaumen- und Lippenspalte mithilfe der Klastro- und Faktoranalyse

Velemínská J.

Die Studie geht aus von der Beobachtung der lateralen Telerőngenaufnahmen von 48 zehnjährigen Jungen mit der kompleten einseitigen Gaumen- und Lippenspalte. Anhand der Klastor- und Faktoranalyse verfolgte man die Beziehung der 75 kraniofazialen Charakteristiken der Grőße, der Form und der Position. Beide diese multivariationsfähigen Methoden haben sich bei der Suche nach den Zusammenhängen zwischen den Teilstrukturen des Kraniums bestätigt. Sie haben sich gegenseitig gut ergänzt und ihre kombinierte Anwendung trug zur Definierung der folgenden grundlegenden und spezifischen Prinzipien der kraniofazialen Beziehungen und der kompensations-adaptierenden Mechanismen bei den Patienten mit der Spalte bei.

Der Oberkiefer besteht aus zwei an sich unabhängigen Teilen. Die vertikalen Parameter des vordrigen Obergesichtes hängen mit dem Hang der Gaumenebene zusammen; der dentoalveolare Teil des Oberkiefers formt sich unabhängig. Dieser Fakt kann man teilweise durch die Auswirkung der orthodontischen Behandlung erklären, die auf bedeutende Weise zur Verbesserung der Gesichtskonfiguration beiträgt. Die Rotation des Unterkiefers beeinflußt das Maß des vordrigen Untergesichtes und auch des ganzen Gesichtes. Sie ist eng verbunden mit der Kőrperposition des Mandibula, jedoch nicht mit der Position seines Zweiges oder seiner Länge. Der Zweighang des Mandibula koreliert mit dem Kinnwinkel, mit dem Goniowinkel und mit dem Hang seines dentoalveolaren Bestandteiles. Dies ist die Folge der Adaptation der Maxillaverkürzung bei der Behaltung des positiven Zusammenbißes. Die Beschädigung der sagitalen zwischenkieferlichen und interalveolaren Beziehungen wird primär durch die Tiefereduktion des Oberkiefers verursacht und hängt mit der Kőrperlänge des Unterkiefers zusammen. Wobei die Beziehung zur Rotation des Mandibula oder zur Länge seines Zweiges wurde nicht beobachtet.

Die Lösung der angegebenen Problematik kann bei der Suche nach den prediktiven Modellen der Gesichtsentwicklung bei Patienten mit der Spalte helfen.

Key words: cleft lip and palate, intracranial relations, cluster and factor analysis, X-ray cephalometry

The Skull is not an unchanging structure and has its own internal dynamic pattern. The size, shape and position of different parts of the skull influence each other to a certain extent. A deviation of one component can cause a series of changes in neighbouring, but also in more remote structures that makes adaptation to the primary abnormality possible. These mutual relations are determined by certain general processes conditioned by the growth rate, proportionality and compensatory and adaptive mechanisms in the skull (Šmahel and Škvařilová, 1988).

An understanding of the mutual craniofacial relations and their mechanisms is of major importance in the field of evolutionary biology, medicine and other scientific disciplines. The literature concerned with the definition and description of mechanisms which regulate the relations between different cranial characteristics is not very extensive. One of the most extensive studies which deals with this craniofacial problem was elaborated by Solow (1966). The author did not only use correlations between different cranial characteristics, which were also followed up in the work of Šmahel and Škvařilová (1988 and 1997). Solow selected factor analysis as an investigative, data reducing method, similarly as did Horowitz et al. (1980). To assess the interrelations between the basic cephalometric facial characteristics and the cranial base, the method of multiple correlation can be used (Šmahel et al., 1977). Björk (1955) analysed the growth mechanism of the cranial base during adolescence, Anderson and Popovich (1982) the relationship of the curvature of this important structure to the shape of the skull and the position of the mandible. In subsequent studies, e.g., the ability of the dentoalveolar component to compensate for disproportions in sagittal intermaxillary relations was investigated, usually based on simple correlation analysis (Steiner, 1959; Varjanne and Koski, 1982; Casko and Shepherd, 1984).

Multivariation analyses were first used in psychology. At present they have a wide spectrum of application in anthropology, zoology and botany for evaluating differences and growth. Within the framework of skeletal anthropology these methods can be used in comparative studies of craniofacial differences of ancient populations (Key and Jantz, 1981; De la Rua, 1992), in orthodontic practice to assess the prognosis of maxillary development and for the selection of suitable treatment (Keeling et al., 1989).

The objective of the present study is to assess the craniofacial morphology and intracranial relations in patients with unilateral clefts of the lip and palate (UCLP), using two different statistical methods that use in their calculations correlations between the assessed characteristics: factor and cluster analysis. The present study compares the two methods and indicates which is more suitable for resolving the problem under investigation.

MATERIAL AND METHODS

The analysis comprised 48 boys with repaired complete unilateral cleft lip and palate without any associated visible malformations. X-ray films were made at the age of approximately 10 years. The mean age at the time of examination was 10 years, 1 month.

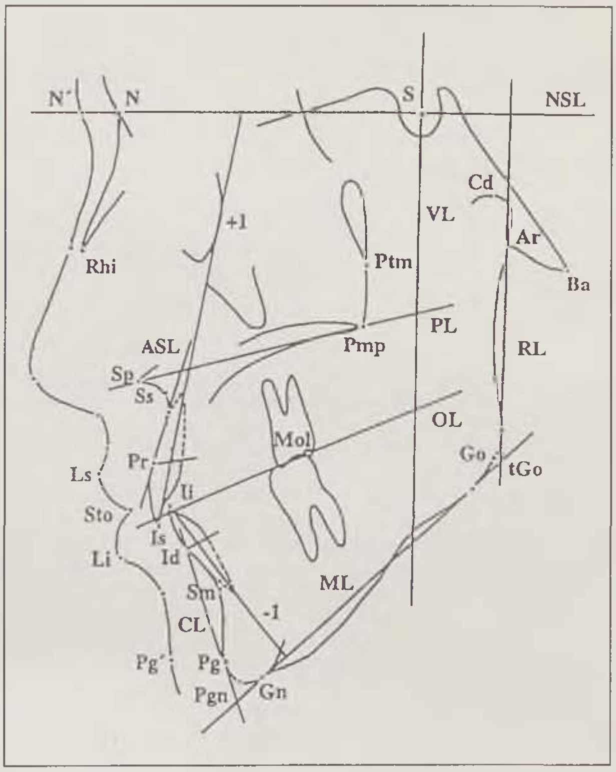

Fig. 1. Cephalometrics points and reference lines used in this study: **Ar** (articulare) - intersection of inferior contour of the clivus and posterior contour of the ramus; **Ba** (basion) - most posteroinferior point on the clivus; **Cd** (condylion) - most superior point on the condylar head; **Go** (gonion) - point on the angle of the mandible determined by the axis of ML/RL angle; **Gn** (gnathion) - lowest point of the mandibular symphysis; **Pgn** (prognathion) - point on the mandibular symphysis farthest from Cd; **Pg** (pogonion) - most anterior point on the bony chin; **Pg'** (soft pogonion) - most anterior point on the soft tissue chin; **Sm** (supramentale) - deepest point on the anterior contour of the mandibular symphysis; **Id** (infradentale) - point of the gingival contact with the lower central incisor; **Ii** (incision inferius) - incisal tip of the lower central incisor; **Is** (incision superius) - incisal tip of the upper central incisor; **Mol** (molare) - tip of the posterior cuspid of the lower first molar; **Pr** (prosthion) - point of gingival contact with the upper central incisor; **Ss** (subspinale) - deepest point of the subspinal concavity; **Sp** (spinale) - tip of the anterior nasal spine; **Pmp** (pterygomaxillare palatinum) - point of intersection of the palate plane and fissure pterygomaxillaris; **Ptm** (pterygomaxillare) - most inferior point of the fossa pterygopalatina where fissura pterygomaxillaris begins; S (sella) - centre of sella turcica; **N** (nasion) - most anterior point on the frontonasal suture; **N'** (soft nasion) - intersection between NSL and soft profile contour; **Rhi** (rhinion) - most anteroinferior point on the nasal bone; **Ls** (labrale superius) - margin of the vermilion of the upper lip; **Sto** (stomion) - point of contact of the upper and lower lip; **Li** (labrale inferius) - margin of the vermilion of the lower lip; **NSL** - line through N and S; **VL** - perpendicular to NSL through S; **PL** - line through Sp and Pmp; **OL** - line passing through the midpoint between incisal tips of the upper and lower central incisors and posterior cuspid of the first lower molar; **+1** - axis of the upper incisor; **-1** - axis of the lower incisor; **CL** - line through Pg and Id; **ASL** - tangent to the maxillar alveolar process through Pr; **ML** - tangent to the mandibular body through Gn; **RL** - tangent to the mandibular ramus through Ar; **tGo** (tangent gonion) - intersection of ML and RL line.

Primary cheiloplasty was carried out according to Tennison at a mean age of 8 months combined with periosteoplasty. Palatoplasty was performed at the age of approximately 5 years and involved push-back and pharyngeal flap surgery. All operations were performed by the same team of surgeons at the Department of Plastic Surgery in Prague. Twenty-five patients were treated with fixed appliances, the remaining patients (23) had only removable appliances to achieve alignment of the teeth and a positive overjet.

The study was based on a cephalometric assessment of lateral X-ray films obtained under standard conditions during centric occlusion with the patient head fixed in a cephalostat. The focus-object distance was 370 cm, the object-film distance 30 cm, the magnification 8.1 %. Craniometric points and reference lines in the assessment of lateral films are presented in figure 1.

The study included an assessment of measurement errors of some of the investigated characteristics. The variance of error, determined on the basis of two measurements, was less than 2 % of the total variance for the relevant parameter. This confirmed the high reliability of the measurements.

All the characteristics selected for our analysis are presented in table 1. The perpendicular distance of a point from the reference line is described as Ar-VL, angles as N-S-Ar or as a fraction of the two reference lines forming the given angle (ML/RL), and proportional characteristics as S-Go%N-Gn (S-Go in per cent of N-Gn). The slope of the axis of the upper incisors to the palate plane is described as +1/PL, of the lower incisors to the mandibular line as - 1/ML. The overjet (Is-Ii) was assessed between the edges of the upper and lower incisors parallel with the occlusal plane. Ls+Li shows the extent to which the upper lip is more prominent at the mentioned points than the lower lip (measured perpendicular to the connecting line N'Pg', i.e. as the difference between the distances Ls-N'Pg'L and Li-N'Pg'L).

Craniofacial interrelations were studied using factor and cluster analysis. Factor analysis describes interrelations between 75 assessed characteristics. The method arranges these characteristics among factors in such a way that they correlate as much as possible with one factor and as little as possible with the other factors. Thus, several (in our model 7) groups of interdependent characteristics are obtained, and our aim is to describe these agglomerations and interpret them reasonably. Cluster analysis divides characteristics into groups based on their mutual distance, in our case 1 - r. Its aim is to search for clusters, i.e. groups of objects: similar objects are in one group, while dissimilar objects are in different groups. An instructive result of the analysis is a tree-shaped dendrogram, which makes analysis of the interrelations of individual branches (clusters) at several levels possible.

RESULTS

Factor analysis was calculated by means of the extended versions of the BMDP programme. Several analytic models of the main component were created, differing as to the type of rotation number of factors and variables. The submitted model comprising 75 variables was selected despite some shortcomings (singular correlation matrix, large number of variables in relation to the number of probands). The reason for this choice was the broad spectrum of the included dimensions, which facilitated an understanding of the assembled results. This model thus appears the most instructive, and, as compared with others, we did not observe a significant difference that could be manifested in a biased interpretation of the subsequent results.

The results of factor analysis are presented in table 1. This table gives the factor loadings (correlations of factors with individual variables), the variance which they explain, and the cumulative ratio of the total variance, explained by the first factor, first and second factor, etc. To each listed factor belongs one faciogram, where if possible all variables are given with appropriate high factor loadings. The values of factor loadings greater than 0.285 are significant at the 5% level of significance (*), values greater than 0.368 at the 1% level of significance (**) and values greater than 0.461 at the 0.1% level of significance (***).

Factor 1 is least specific. As it expresses the interrelationship of size and some positional linear dimensions, we have called it **the factor of linear characteristics** (Fig. 2). The closest associations were found between the factor and heights of the anterior and posterior face S-Go (0.937), Cd-Go (0.840), N-Gn (0.781) and others; least dependent is the depth of the maxilla Ss-Pmp (0.335), the dimension N-Rhi (0.268), i.e., dimensions with a closer relationship to other factors, and some calculated and positional dimensions. The associations between linear characteristics are illustrated by the dendrogram of cluster analysis (see Fig. 9). There is branch V8, which unifies the linear dimensions of the posterior face and posterior cranial base, branch V11, which except for the total anterior facial height, agglomerates the heights of the upper anterior face, and the branch of mandibular rotation V9, which comprises the height dimensions of the anterior lower face.

Factor 2 is, beyond doubt, **the factor of sagittal intermaxillary and interalveolar relations** (Fig. 3). The highest values of factor loadings are attained by dimensions that directly express these sagittal relationships such as Pr-N-Id (0.947), Ss-N-Sm (0.911), Pr+Id (0.840), and Ss+Sm (0.728). The factor also associates the main causes of damage to sagittal intermaxillary relations in patients with clefts, i.e., the reduced depth of the maxilla Ss-Pmp (0.601) and the mandibular length Pgn-Go (-0.435). As a result of

Table 1. Factor loadings of the calculated factors with different variables, the ensuing variance and cumulative ratio of factors in the total variance

	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7
S-Go	0.937***	0	0	0	0	0	0
S-tGo	0.931***	0	0	0	0	0	0
S-Pgn	0.859***	0	0.345*	0	0	0	0
Cd-Go	0.84***	0	0	0	0	0	0
Pmp-NSL	0.8***	0	0	0	0	0	0
N-Gn	0.781***	0	0.553***	0	0	0	0
N-Pr	0.728***	0	0.484***	0	0	0	0
N-Ss	0.713***	0	0	0	0	0	0.443**
S-Ar	0.713***	0	0	0	0	0	0
Cd-NSL	0.658***	0	-0.268	0	0	0	0
Mol-ML	0.649***	0	0	0	0	0.378**	0
S-Ba	0.617***	-0.378**	0	0	0	0	0
N-Sp	0.612***	0	0	0.36*	0	0	0.598***
Mol-PL	0.561***	0	0.389**	0	0.338*	0	-0.287*
Pr-Id	0.525***	0	0	0	0.273	0	-0.258
Pr-N-Id	0	0.947***	0	0	0	0	0
N-Ss-Pg	0	-0.914***	0	0	0	0	0
Ss-N-Sm	0	0.911***	0	0	0	0	0
Ls-N'Pg'L	0	0.866***	0	0	0	0	0
Pr+Id	0	0.84***	0	0	-0.289*	0	0
Sto-N'Pg'L	0	0.804***	0	0	0	0	0
Is-NPgL	0	0.789***	0	0	0.338*	0.311*	0
Is-Ii	0	0.732***	0	0	0	-0.264	0.335*
Ss+Sm	0	0.728***	0	0	-0.442**	0	0
S-N-Ss	0	0.611***	0	-0.567***	0	0	0
Ss-Pmp	0.335**	0.601***	0	0	0	0	-0.254
Ls+Li	0	0.593***	0	0	-0.481***	0	0
Li-N'Pg'L	0	0.568***	0.325*	0	0.439**	0	0
ML/NSL	0	0	0.919***	0.339*	0	0	0
StGo%NGn	0.263	0	-0.889***	0	0	0	0
SGo%NGn	0.265	0	-0.88***	-0.25	0	0	0
PL/ML	0	0	0.872***	0	0	0	-0.318*
N-tGo-Gn	0	0	0.846***	0	0	0	0
Id-Gn	0.559***	0	0.658***	0	0	0	0
Ii-Gn	0.632***	0	0.656***	0	0	0	0
Sp-Pg	0.614***	0	0.649***	0	0	0	-0.323*
Id-Sm	0	0	0.598***	0	0	0	0
Sp-Is	0.507***	0	0.58***	0	-0.283	0	-0.407**
Pr-PL	0.4**	0	0.554***	0	0	0	-0.399**
-1/ML	0	0.352*	-0.529***	0	0.266	0.471***	0
N-S-Ar	0	0	0	0.939***	0	0	0
Pmp-VL	0	0	0	-0.836***	0	0	0
N-S-Ba	0	0	0	0.835***	0	0	0
Ar-VL	0.398**	0	0	0.819***	0	-0.281	0
Ptm-VL	0	0	0	-0.815***	0	0	0
N-S-Cd	0	0	0	0.795***	0	0	0
N-S-Go	0	0	0.271	0.764***	0	0.388**	0
N-S-Pgn	0	0	0.545***	0.664***	0	0.332**	0
S-N-Pg	0	0	-0.401**	-0.644***	0.443**	-0.293*	0
S-N-Sm	0	0	-0.342*	-0.64***	0.553***	0	0
S-N-Gn	0	0	-0.405**	-0.615***	0.445**	-0.314*	0
S-N-Sp	0	0.528***	0	-0.582***	0	0	-0.265
S-N-Pr	0	0.557***	0	-0.572***	0.474***	0	0
+1/PL	0	0	0	0	0.834***	0	0
+1/NSL	0	0	0	0	0.76***	0	0
ASL/PL	0	0	0	0	0.757***	0	0.365*
S-N-Id	0	0	-0.252	-0.618***	0.64***	0	0
Ar-tGo-N	-0.267	0	0	0	0	-0.836***	0
RL/NSL	0	0	0	0.32*	0	0.82***	0
S-Ar-tGo	0	0	0	-0.505***	0	0.8***	0
ML/RL	0	0	0.642***	0	0	-0.648***	0
CL/ML	0	0.429**	0	0	0	0.584***	-0.263
Ii-NPgL	0	0.4**	0	0	0.505***	0.564***	-0.303*
-1/NSL	0	-0.436**	0	-0.301*	0	-0.532***	0
PL/NSL	0	0	0	0.36*	0	0	0.726***
NSp%NGn	0	0	-0.54***	0	0	0	0.715***
N-Rhi	0.268	0	0	0.365*	0	0	0.55**
Is+Ii	-0.43**	0	0	0	-0.449**	0	0.353*
Sp-Pmp	0.372**	0.445**	0	0	0	0	0.333*
S-N-Rhi	0	0.361*	0	-0.479***	0.269	-0.275	-0.271
OL/NSL	0	0	0.456**	0.394**	0	0	0
Pgn-Go	0.485***	-0.435**	0.308*	0	0	0	0
N-S	0.486***	0	0	0	-0.349*	0	0
+1/-1	-0.261	0	0	0.346*	0	0	0
Pmp-Ba	0.497***	0	0	0	0	-0.361*	0
variance explained	16,835	12,165	11,234	6,754	4,916	3,53	2,801
cumulative proportion of variance	0.289	0.498	0.691	0.807	0.891	0.952	1

this the convexity of the face N-Ss-Pg (-0.914) is reduced, changes of occlusion develop Is-Ii (0.732), and the position of the incisors in relation to the NPg line Is-NPgL (0.789), Ii-NPgL (0.400) changes as well as the position of the lips in relation to the N'Pg'line of the soft profile Ls-N'Pg'L (0.866), Li-N'Pg'L (0.568), Sto-N'Pg'L (0.804). The factor also integrates, in the wider sense of the word, characteristics which represent the main adaptive mechanisms of this damage if a positive

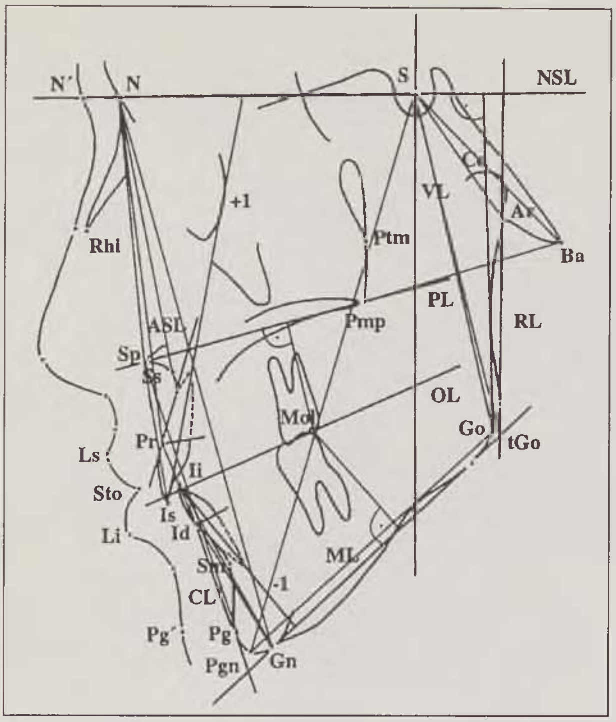

Fig. 2. Faciogram in lateral projection with variables which related with **factor of linear characteristisc** (factor 1). Measured distances are marked by straight lines.

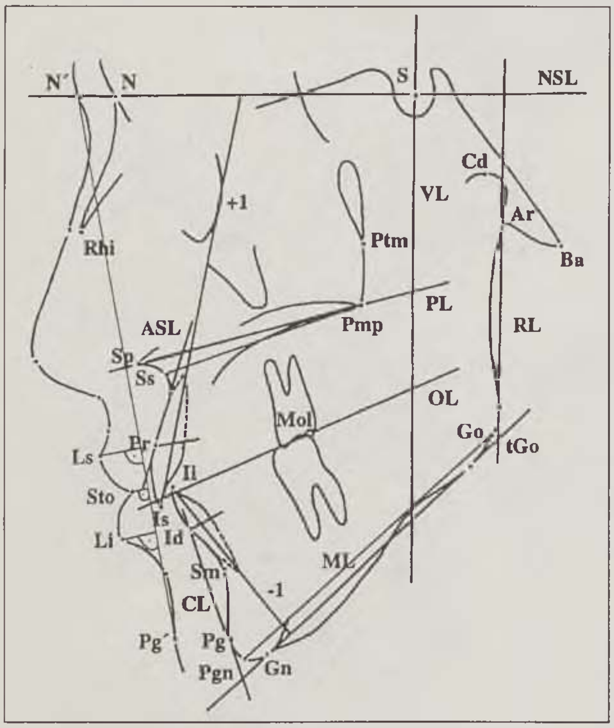

Fig. 3. Faciogram in lateral projection with variables related with **factor of sagittal maxillomandibular relations** (factor 2). Measured distances are marked by straight lines. Thin lines are auxiliary.

overjet is preserved. They include retrusion of the lower incisors -1/NSL (-0.436) and a sharper angle of the chin CL/ML (0.429). The association with the posterior length of the cranial base S-Ba (-0.378) is of interest. Almost identical results are also provided by cluster analysis in the shape of branch V15, which agglomerates branch V3 (sagittal intermaxillary relations in the soft profile), branch V4 (adaptive mechanisms of damage to sagittal intermaxillary relations) and branch V5 (sagittal intermaxillary relations and causes of their damage).

Factor 3 is the factor of mandibular rotation (Fig 4). The rotation of the mandible is expressed by the lower portion of the gonial angle N-tGo-Gn (0.846), and it can also be calculated as the ratio of the heights of the posterior and anterior face expressed in per cent S-tGo%N-Gn (- 0.889), S-Go%N-Gn (-0.880). Rotation of the mandible correlates with the height dimensions of the anterior face Id-Gn (0.658), Ii-Gn (0.656), depth of the face S-Pgn (0.345) and also with the anterior height of the whole face N-Gn (0.553). Logical deductions can also be made on an association with the protrusion of the chin N-S-Pgn (0.545), or a possible association with the protrusion of the whole mandible, which is defined by a number of anglular characteristics S-N-Pg (-0.401), S-N-Sm (-0.342), S-N-Gn (-0.405). Also related with the rotation of the mandible are the inclination of the lower incisors in relation to its body -1/ML (-0.529), the slope of the occlusal plane OL/NSL (0.456) and the length of the mandibular body Pgn-Go (0.308). As to factor loadings of the investigated factor, a relationship of mandibular rotation with the position of its body can be proved ML/NSL (0.919), PL/ML (0.872), but not with the position of its branch RL/NSL or maxillary joint N-S-Cd (factor loadings with zero values). In the dendrogram the branch V9 corresponds with the mandibular rotation. This clusters, however, paradoxically does not comprise the calculated percentage ratio of heights of the posterior and anterior face which directly expresses the mandibular rotation. This is due to a different sign of the given characteristic, as compared with the other unified dimensions in the branch where it logically should belong (in more detail in the discussion).

Factor 4 is the factor of rotation of the neurocranium (Fig. 5), which describes the position of different facial structures in relation to the NS line, possibly the VL line. The rotation of the neurocranium ensues from the angle of the cranial base N-S-Ba (0.835) and is associated with the position of the majority of craniometric points expressed in many angular characteristics N-S-Ar (0.939), N-S-Cd (0.795), N-S-Go (0.764), N-S-Pgn (0.664), S-N-Pg (-0.644), S-N-Sm (-0.640), S-N-Gn (-0.615), S-N-Sp (-0.582), S-N-Pr (-0.572), S-N-Id (-0.618), S-N-Rhi (-0.479). The angles with top in the point S have positive signs; angles with top in the point N have negative signs. This fact expresses the mutual relationship of the two subgroups of angles. In a simplified way it can be interpreted as follows: with increasing values of one group of angular characteristics, the values of

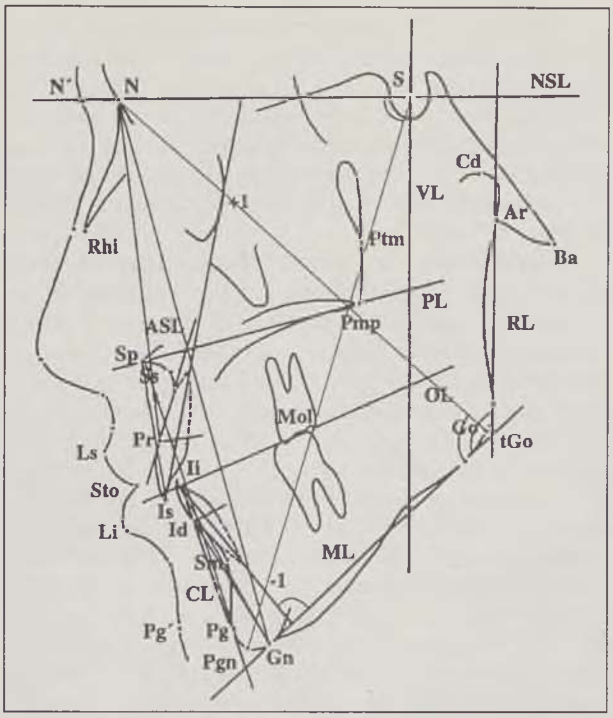

Fig. 4. Faciogram in lateral projection with variables related with **factor of rotation of the mandible** (factor 3). Measured distances are marked by straight lines, measured angles by arches. Thin lines are auxiliary.

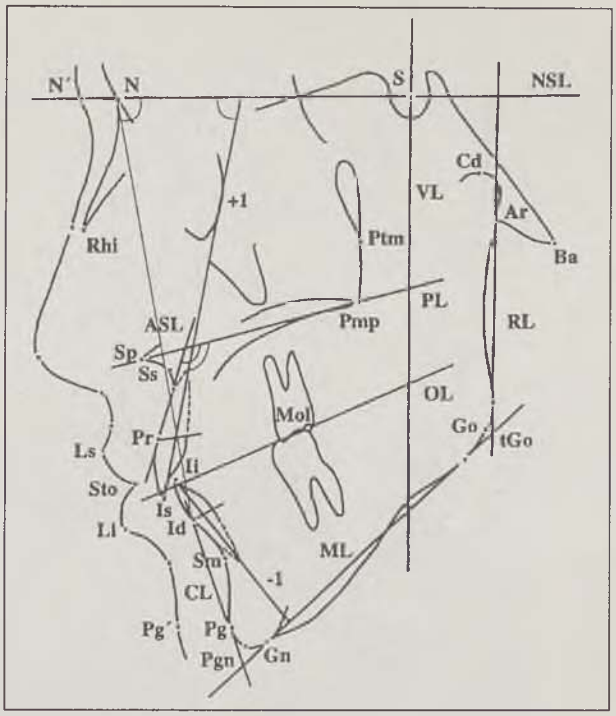

Fig. 6. Faciogram in lateral projection with variables related with **factor of the inclination of the upper alveolar process** (factor 5). Measured angles are marked by arches. Thin lines are auxiliary.

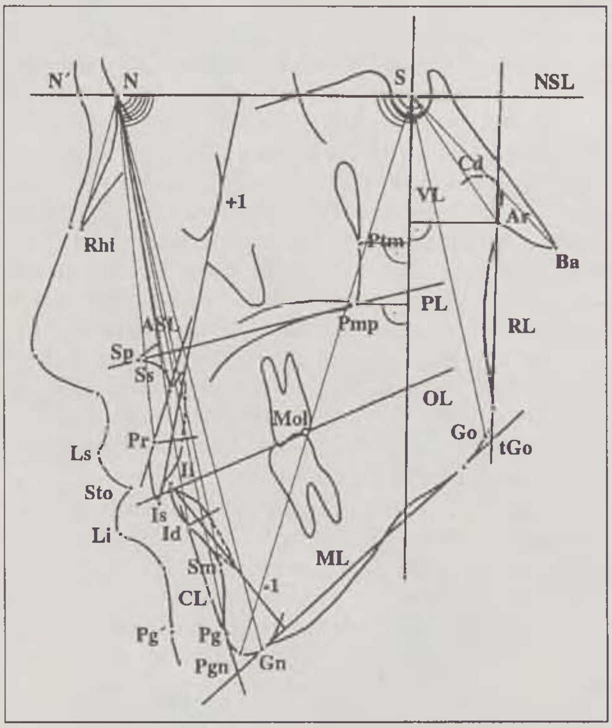

Fig. 5. Faciogram in lateral projection with variables which related with **factor of rotation of the neurocranium** (factor 4). Measured distances are marked by straight lines measured angles by arches. Thin lines are auxiliary.

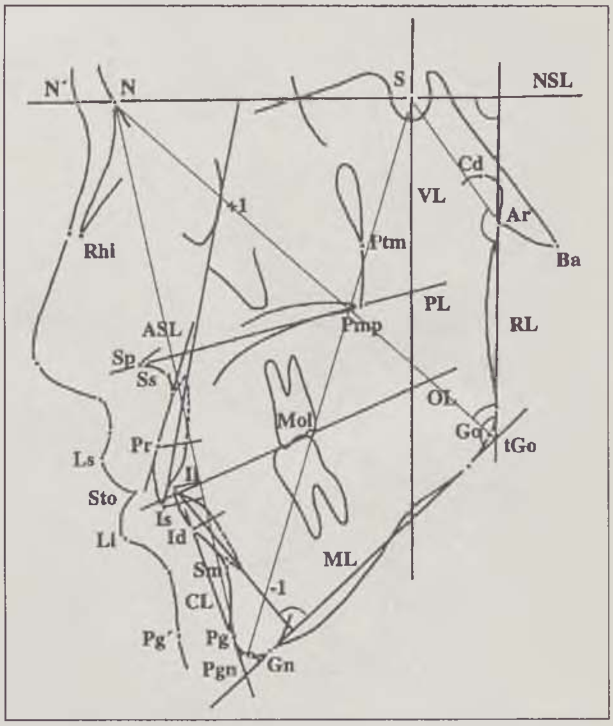

Fig. 7. Faciogram in lateral projection with variables related with **factor of the mandibular shape** (factor 6). Measured distances are marked by straight lines, measured angles by arches. Thin lines are auxiliary.

the other group diminish, thus the face of subjects with a larger angle of the cranial base develops posterioration and vice versa. These associations cannot be detected by means of the applied dendrogram as the two above-mentioned dependent groups of angular positional characteristics are visualized as two independent branches of the dendrogram (V1 and V10).

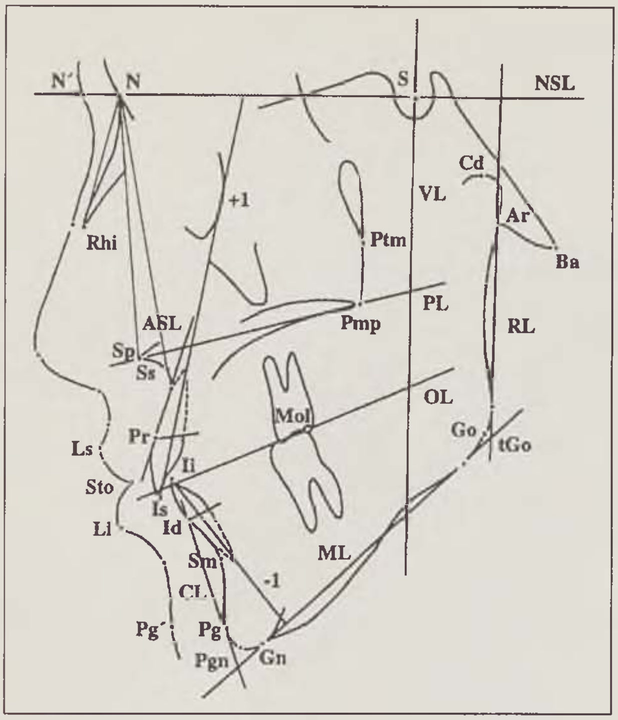

Fig. 8. Faciogram in lateral projection with variables related with **factor of heights of the upper anterior face** (factor 7). Measured distances are marked by straight lines.

Factor 5 can be defined as **the inclination factor of the alveolar process** (Fig. 6).This term comprises not only the slope of the alveolar process proper ASL/PL (0.757) but also the slope of the upper incisors in relation to the anterior cranial base +1/NSL (0.760) or the palate plane +1/PL (0.834). These structures can compensate to a certain extent for impaired sagittal maxillary relations in the area of the maxilla (Pr+Id -0.289, Ss+Sm -0.442, Ls+Li -0.481 and others). They can be readily influenced by orthodontic treatment, the main objective of which is, in addition to aligning the teeth in the alveolar arch, to eliminate or at least mitigate the maxillary retrusion and thus also some of its consequences. In addition to the described association with sagittal intermaxillary relations, there is also an obvious relationship with the protrusion of different mandibular structures (S-N-Pg 0.443, S-N-Sm 0.553 etc.). Cluster analysis does not explain the compensatory ability of the maxilla very well, as it describes only branch V6, which unifies the dimensions that express the slope of the upper alveolar process and the upper incisors.

Factor 6 describes the shape of the mandible, the position of its vertical components (of the branches and alveolar process) (Fig. 7) and of the temporo-mandibular joint in relation to the other cranial structures Ar-tGo-N (-0.836), RL/NSL (0.820), S-Ar-tGo (0.800), ML/RL (-0.648), CL/ML (0.584), -1/NSL (-0.532), -1/ML (0.471). The mentioned characteristics are not associated in the majority with the mandibular rotation but express its compensatory abilities, which are consistent with the reduced growth of the maxillary depth. According to the signs of the above-mentioned structures, the compensatory mechanism of the mandible can be described in more detail. With an increasing Ar-tGo-N angle the maxillary joint shifts in a posterior direction, the gonial angle (ML/RL) increases, while the angles of the chin (CL/ML) and lower incisors in relation to the plane of the mandibular body (-1/ML) become sharper. Neither the length of the branch of the mandible (Pgn-Go) nor its body (Cd-Go) are associated with the compensatory mechanism of the mandible according to the models of factor or cluster analysis used. Corresponding with this factor in the dendrogram are branches V4 and V13, which apparently are not associated due to the different signs of the correlation coefficients on which the method is based. The advantage of the dendrogram employed is, in this case, an illustration of the association between the compensatory abilities of the mandible and sagittal intermaxillary relations (branch V15).

Factor 7 (Fig. 8) **is the factor of the heights of the anterior upper face** N-Sp (0.598), N-Rhi (0.550), and N-Ss (0.443). The existence of this factor provides evidence that the development of the anterior face has an impact on the slope of the palate PL/NSL (0.726), but is not associated with the formation of the alveolar process of the maxilla or mandible. Branch V11 in the dendrogram corresponds with the factor.

Cluster analysis calculated by means of the „Statistika" programme resolves craniofacial relations at many levels, starting with relations of two dimensions to the main two branches of the dendrogram (see Fig. 9). The numbered branches of the dendrogram indicate the more important groups of characteristics that describe the structure of the cranium, or possibly some of its interrelations. Some branches correspond to the above-mentioned factors, more frequently several branches of the dendrogram correspond with the factors. The shorter the branch (complete linkage distance), the more the dimensions are associated. The closest correlation was found between characteristics S-tGo and S-Go, i.e., dimensions which are almost identical.

Another, let us say higher level of cluster analysis provides information about how the different listed cranial structures are related. The whole tree can be divided into two main branches that describe the entire cranium. The first branch (V16) describes the close relationship of sagittal intermaxillary relations with shapes of the mandible and the soft profile in the area of the lips. The described structures are more loosely associated with the branch that characterises the position of individual craniometric points of the skeletal profile in relation to the neurocranium.

The second main branch (V17) associates several partial structures, such as groups of linear dimensions of different cranial areas (V8, V11,

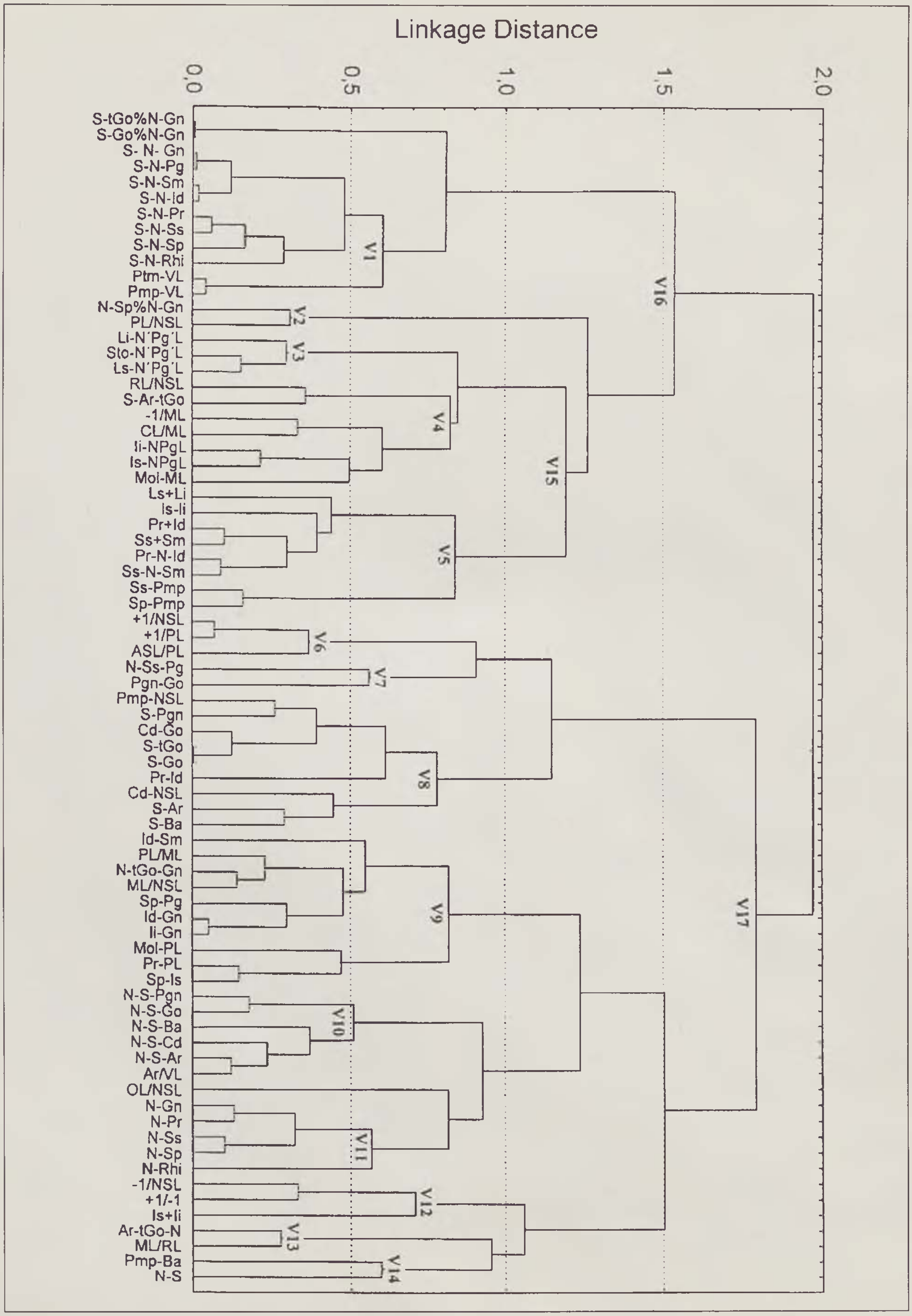

Fig. 9. Tree diagram for 75 variables, complete linkage 1 - Pearson r.

V14), rotation of the neurocranium (V1 and V10) or the mandible (V9) and some dentoalveolar characteristics. Dentoalveolar dimensions were projected into two subgroups. Branch V6 can be described as the slope of the dentoalveolar component of the maxilla. Another subgroup (V12) is the dimensions that comprise the dental component of the upper as well as lower jaw (+1/-1, Is+Ii). The association between dimensions describing the rotation of the neurocranium and height of the anterior and, in particular, the upper face is of interest. Some associations between characteristics seem to be purely mathematical.

DISCUSSION

The objective of the investigation was to seek intracranial relations in patients with clefts by means of two statistical methods - factor and cluster analysis. Both methods are based on correlation analysis of the investigated characteristics. The former method associates the characteristics to factors that closely correlated with them, while their correlation with other characteristics is as low as possible. Cluster analysis in the actual form of dendrograms divides the characteristics into different agglomerations based on the distance 1-r (r = Pearson correlation coefficient).

The advantage of factor analysis, as compared with the use of the dendrogram, is the possible unification of dimensions with different signs of correlation coefficients (see table 1). On the other hand, in dendrograms correlations with positive and negative signs seem to be two special and apparently unassociated branches. A suitable example is the factor of sagittal intermaxillary relations. This factor 2 includes e. g. also the convexity angle of the face, which is, no doubt, associated with the intermaxillary relations. In the dendrogram this association cannot be found because with deteriorating saggital intermaxillary relations (decreasing of the dimensions Ss-N-Sm, Ss+Sm, Pr-N-Id, Is-Ii) the face becomes more concave (increasing angle N-Ss-Pg). The advantage of cluster analysis is the possibility to follow-up not just the mutual interrelations between different dimensions. The method also investigates associations between groups of dimensions that correspond to the formation of facial structures in patients with clefts. This pertains to relations between minor groups of characteristics, as well as to those between major agglomerations of characteristics that represent whole structures of the cranium or some interrelations. The dendrogram provides clear evidence of associations, e.g., between the above-mentioned sagittal intermaxillary relations and the mandible. Rotation of the mandible does not exert a significant effect on the maxillary and alveolar relations. The shape of the mandible expressed as the position of its branch (S-Ar-tGo), the steepness of the chin (CL/ML) and the slope of the lower incisors (-1/ML) are closely associated with the investigated sagittal relations.

To date, we have not encountered in the literature results of cluster analysis concerned with a similar subject. The results of factor analysis can be, to a limited extent, compared with the investigation of Solow (1966). However, the author also included in factor analysis somatic characteristics and dimensions of the width of the neurocranium and face. Some dimensions are defined in a different way and thus the length of the mandible is described as dimension Pgn-Cd, while we use in our investigation the length of the body (Pgn-Go) and length of the branch (Cd-Go). Solow classified the characteristics among 19 factors and only 6 (factors 5, 7, 8, 9, 10 and 11) indicate some agreement with our results. Factor 5, similarly as our factor 12, unifies the linear dimensions, and we can observe a very close relationship between the dimensions of the posterior part of the neurocranium and the face. Both papers describe the influence of the curvature of the cranial base on the position of both jaws, the relationship between the depth (length) of the maxilla and its protrusion, the relation between height dimensions of the anterior upper face and the slope of the palate plane, and the negative association of the slope of the upper incisors and overjet. In both investigations the steeper slope of the mandibular body in relation to the NS line is related to the height dimensions of the lower face, and this leads in patients with clefts to damage to the vertical intermaxillary relations.

Other comparisons with data from the literature are difficult as the results of similar methods are not compared but rather interpreted associations, and this may lead to inaccuracies. The angle of the cranial base does not differ significantly in patients with clefts from controls (Šmahel and Brejcha, 1983). Orthodontic patients with class II malocclusion have on average a greater angle of the cranial base than patients of class III (Keeling et al., 1989). The association between the rotation of the neurocranium and the facial configuration, its rotation and the position of both jaws, confirmed in the present investigation, has been known for a long time (Björk, 1955). Neither the slope of the alveolar processes nor that of the upper and lower incisors is associated with the angle of the cranial base. This is consistent with the work of Šmahel and Škvařilová (1988). These structures are closely related with the adaptive abilities of both jaws.

The linear dimensions are as a rule more associated mutually than with shape characteristic, as confirmed by the existence of factor 1. Linear dimensions of the anterior upper face, the anterior lower face and the posterior face and longitudinal measurements of the cranial base are more interrelated within these groups (see dendrogram) than with other linear dimensions. This fact can be explained by a different type of growth of these different parts of the cranium. The mentioned findings are on the whole consistent with the partial relations of individual linear dimensions in the investigation published by Šmahel and Škvařilová (1988).

The mandible has, as compared with the maxilla, a greater adaptive capacity in case of impaired sagittal intermaxillary relations, which again is consistent with the above-mentioned authors. The mandible can adapt not only in the area of the alveolar process and incisors but also by a change in the position of the temporomandibular joint, the slope of the mandibular branch, and changes in the gonial and chin angles. The reduction of the longitudinal parameters of the mandible in patients with clefts does not nearly correspond to the great reduction of the maxillary depth (Šmahel and Brejcha, 1983), which in the long run leads to damage to the sagittal intermaxillary relations. Rotation of the mandible, according to the results of our investigation, is not associated with its compensatory abilities and is probably governed by congenital growth patterns. The authors observed an association between the rotation of the mandible and the length of its body. Surprisingly, the length of the branch of the mandible is not associated with its shape or rotation, which is at variance with the results of Šmahel and Škvařilová (1988).

CONCLUSIONS

1. The basic intracranial relations can be derived by means of both of the applied methods.
2. In more detailed studies of the problem, it is better to use both methods simultaneously. The advantage of combined use is not only to test the results but also the fact that the methods complement each other: one helps to eliminate the shortcomings of the other and thus combined they make a more detailed analysis of the investigated problem possible.
3. Rotation of the neurocranium has an impact on the configuration of different facial components.
4. Linear dimensions of the same area of the cranium and in the same direction follow the same type of growth and therefore are closely related.
5. A reduced depth of the maxilla is most closely related to sagittal intermaxillary relations as it is the main cause of their damage.
6. Rotation of the mandible is closely associated with the heights of the anterior face and with protrusion of the mandible.
7. The anterior upper face develops independently in relation to its other parts. The slope of the dentoalveolar process of the maxilla can be influenced by orthodontic treatment, and in case of a positive overjet it has an impact on the shaping of the mandible.
8. Sagittal intermaxillary relations of patients wit clefts are more closely associated with the shape of the mandible and the position of its branch in relation to the neurocranium than the type of its rotation.

REFERENCES

1. Anderson, D., Popovich, F. Relation of cranial base flexure to cranial form and mandibular position. *Am. J. Phys. Anthropol.*, 61: 181-187, 1983.

2. Björk, A. Cranial base development. *Am. J. Orthodont.*, 41: 198-225, 1955.

3. Casko, JS., Shepherd, WB. Denthal and skeletal variation within the range of normal. *The Angle Orthod.*, 54: 5-17, 1984.

4. Horowitz, SL., Graf, B., Bettex, M., Winkka, H., Gerstman, LJ. Factor analysis of craniofacial morphology in complete bilateral cleft lip and palate. *Cleft Palate J.*, 17: 234-244, 1980.

5. Keeling, SD., Riolo, ML., Martin, RE., Ten Have, TR. A multivariate approach to analysing the relation between occlusion and craniofacial morphology. *Am. J. Othod. Dentofac. Orthop.*, 95: 297-305, 1989.

6. Key, P., Jantz, RL. A multivariate analysis of temporal change in Arikara. *Am. J. Phys. Anthropol.*, 55: 247-259, 1981.

7. de la Rua, C. Craniofacial factors in the Basque skull. A comparative study. *Homo*, 43: 135-161, 1992.

8. Šmahel, Z., Brejcha, M. Differences in craniofacial morphology between complete and incomplete unilateral cleft lip and palate in adults. *Cleft Palate J.*, 20: 51-65, 1983.

9. Šmahel, Z., Müllerová, Ž., Škvařilová, B. Multiple correlations between craniometric characteristics in early childhood: an X-ray study. *Anthropologie*, XXXV: 77-84, 1997.

10. Šmahel, Z., Škvařilová B. Multiple correlations between craniofacial characteristics: an X-ray study. *Am. J. Phys. Anthropol.*, 77: 221-229, 1988.

11. Šmahel, Z., Škvařilová, B. Roentgencephalometric study of cranial interrelations. *J. Craniofac. Genet. Dev. Biol.*, 8: 303-318, 1988.

12. Škvařilová, B., Müllerová, Ž., Šmahel, Z. Roentgencephalometric study of intracranial relations in early childhood. *Anthropologie*, XXXV: 65-76, 1997.

13. Solow, B. The pattern of craniofacial associations. *Acta Odont. Scand.*, 24 (Suppl 46): 1-140, 1966.

14. Varjanne, I., Koski, K. Cranial base, sagittal jaw relationship and occlusion. *Proc. Finn. Dent. Soc.*, 78: 179-183, 1982.

Address for correspondence:

Jana Velemínská
Viničná 7
128 44 Prague 2
Czech Republic

SOUHRNY

Účinek silikonem potaženého polyamidového síťového obvazu a kalcium alginátu na hojení místa odběru štěpeného kožního štěpu: prospektivní randomizovaný pokus

O'Donoghue J. M., O'Sullivan S. T., O'Shaughnessy M., O'Connor T. P. F.

Byl proveden otevřený randomizovaný prospektivně řízený pokus pro stanovení účinnosti hojení, míry skluzu a stupně nepohodlí při sejmutí kalcium alginátového a silikonem potaženého polyamidového síťovaného obvazu v místě odběru štěpeného kožního štěpu. Náhodně bylo vybráno 16 pacientů do skupiny s obvazem obsahujícím kalcium alginát a 14 pacientů do skupiny s obvazem potaženým silikonem. Místa odběru byla posuzována od 7., 10., 14. dne až do 21. dne. Průměrná doba hojení ve skupině kalcium alginátu byla 8,75 ± 0,78 dnů (v rozmezí od 7 do 14 dnů) v porovnání s 12 ± 0,62 dny (v rozmezí 7 až 16 dnů) pro skupinu opatřenou silikonem ($p < 0,01$). Ačkoli více sklouzávaly silikonem potažené obvazy (5:1), rozdíl nebyl statisticky významný. Bolest během první obvazové výměny byla stanovena pomocí vizuální analogové stupnice bolesti. Ačkoli nebyly nalezeny žádné signifikantní rozdíly mezi skupinami, bylo nezbytné změnit obvazový protokol u silikonem opatřené paže po zahájení u prvních dvou pacientů. Vrchní absorpční gáza přiléhající k místu odběru přes fenestrace v obvazu vyžadovala umístění parafinované gázy mezi experimentální obvaz a překrývající bavlněnou gázu. Ve studii byla zjištěna jedna infekce, ke které došlo v alginátové skupině. Na základě výsledků doporučujeme kalcium alginát jako možný výběr obvazu pro štěpený kožní štěp místa odběru.

Fyziologické rozdíly v citlivosti a pocení v typických místech odběrů kožních a fasciokutánních volných laloků

Ahčan U., Arnež Z. M., Kristan A.

U 30 zdravých dobrovolníků (20 mužů a 10 žen) ve věku 17 až 62 let (v průměru 38,2 roku) byly sledovány rozdíly v citlivosti a pocení v typických místech odběrů kožních a fasciokutánních volných laloků (lopatkový, zevní strana paže, radiální strana předloktí, tříslo a hřbet nohy).

Byly užity standardní klinické metody: Semmens-Weinsteinova metoda pro testování lehkého dotyku s užitím monofilního vlákna, tupý kaliper pro hodnocení statického a dynamického rozlišení dvou bodů a Marschtockova kvantitativní metoda pro určení norem rozlišení tepla a chladu a tepelného a chladového prahu bolesti. Samovolná sekrece potu byla sledována a dokumentována pomocí ninhydrinového testu.

Autoři stanovili fyziologické rozdíly v citlivosti a pocení mezi uvedenými částmi těla (místa odběrů kožních a fasciokutánních volných laloků).

Popis případu: volný arterializovaný venózní lalok užitý pro rekonstrukci defektu po odstranění intraorálního karcinomu

Cunha-Gomes D., Bhathena H., Kavarana N. M.

Volný arterializovaný venózní lalok s v. cephalica je dobrou možností pro intraorální rekonstrukci. Použití tohoto laloku, který poskytuje tenkou a poddajnou kůži, umožňuje jednodobou rekonstrukci bez obětování hlavního arteriálního kmene. Tento lalok může pomoci překlenout problém v případě, kdy ruka má dominantní cévní zásobení z a. radialis.

CO_2 a Nd:YAG laserová asistence při obnově nervů: studie o síle propojení a tepelném poškození

Menovsky T.

Srovnávací studie byla pořízena pro zlepšení laserového svařování. Zkoumá kritičnost síly propojení a tepelného poškození následkem CO_2 a Nd:YAG laserové asistence při obnově nervů provedené s užitím nebo bez užití krevního albuminu jako pájky. Nejsilnější spoje byly vytvořeny s CO_2 laserem užívajícím albumin jako pájku. Tepelné poškození bylo nejmenší s CO_2 laserem, zatímco při použití Nd:YAG laseru bylo poškození závažné. Vysoká síla propojení kombinovaná s minimálním poškozením nervu následkem obnovy CO_2 laserem při použití albuminu opravňuje další výzkumy užití této techniky při studiích in vivo.

Operace rozštěpu patra dvojitou reverzní Z-plastikou: první hodnocení výsledků řeči ve věku 6 let

Vokurková J., Mrázek T., Výška T., Pešlová M., Veselý J.

Bylo zhodnoceno prvních 15 šestiletých dětí operovaných pro rozštěp patra dvojitou reverzní Z-plastikou. Vyšetření chirurgem neprokázalo zavedením nové operační metody zhoršenou morbiditu. Vyšetření foniatrem prokázalo výrazné zlepšení řečových funkcí ve srovnání s předchozí metodou dle von Langenbecka. Výsledky jsou předběžné, na malém souboru pacientů.

Analýza intrakraniálních vztahů u pacientů s jednostranným rozštěpem rtu a patra pomocí klastrové a faktorové analýzy

Velemínská J.

Studie byla založena na kefalometrickém sledování laterálních telerentgenových snímků 48 desetiletých chlapců s kompletním jednostranným rozštěpem rtu a patra. Za použití klastrové a faktorové analýzy byl sledován vztah 75 kraniofaciálních charakteristik velikosti, tvaru i pozice. Obě multivariační metody se při hledání souvislostí mezi dílčími strukturami krania osvědčily. Vhodně se doplňovaly a jejich kombinované použití přispělo k definování následujících základních i specifických principů kraniofaciálních vztahů a kompenzačně-adaptačních mechanismů u rozštěpových pacientů.

Horní čelist se skládá ze dvou na sobě téměř nezávislých částí. Vertikální parametry předního horního obličeje souvisejí se sklonem roviny patra, dentoalveolární složka horní čelisti se formuje nezávisle. Tento fakt lze částečně vysvětlit působením ortodontické léčby, která podstatně přispívá ke zlepšení konfigurace obličeje. Rotace dolní čelisti ovlivňuje vertikální rozměry jak předního dolního, tak i celého obličeje a je těsně spjata s pozicí těla mandibuly, ne však s pozicí její větve, ani s její délkou. Sklon větve mandibuly koreluje s úhlem brady, s goniovým úhlem a se sklonem její dentoalveolární složky, což je důsledek adaptace na zkrácení maxily při zachování pozitivního skusu. Poškození sagitálních mezičelistních a interalveolárních vztahů je primárně způsobeno redukcí hloubky horní čelisti a souvisí s délkou těla dolní čelisti, zatímco vztah k její rotaci ani délce větve nebyl zaznamenán.

Řešení dané problematiky může pomoci při hledání prediktivních modelů vývoje obličeje u pacientů s rozštěpovými vadami.

INSTRUCTIONS TO AUTHORS

Acta Chirurgiae Plasticae, the international journal of plastic surgery, is published in English four times a year. For publication are accepted articles dealing with problems of plastic, reconstructive and aesthetic surgery, craniofacial surgery, hand surgery, microsurgery, burns and allied branches (clinical, laboratory, experimental studies); they must be submitted in English or Czech language. They must be original and not previously published elsewhere.

Kindly send your manuscripts to the following address: **Acta Chirurgiae Plasticae, Šrobárova 50, 100 34 Prague 10, Czech Republic.**

The manuscript must be typewritten in two copies, one page per sheet, with doublespacing between the lines, 60 types per line and no more than 30 lines per page. There should not be more than five corrections by handwriting per manuscript. The institute where the authors work, the title of the article and the name of the author (of authors), must be stated on the first page. All other pages should be numbered consecutively. The summary with key words, the references in alphabetic order according to the surname of the first author and the legend to the Figures are to be written each on a separate page and added to both copies of the manuscript. The address of the main author must be given at the bottom of the References. The place where the Tables are to be inserted should be marked in pencil on the margin of the text. Figures are to be separate and not affixed in the text. On the back of each Figure, the author is requested to write in soft pencil his name, the short title of the paper and the consecutive number of the illustration with an arrow indicating the top of the Figure. Photographs must be clear, with good contrast and of a convenient size. Colour photographs are accepted for reproduction as well. The Tables and Graphs should be lined with Indian ink on white paper so as to make them well readable. The Tables must be numbered consecutively with Arabic numerals and typed on separate pages.

References should be quoted in the text with surname of the author and the year of publication. Two or more works by the same authors published in the same year must be marked with the suffixed a, b, c, etc. Quotations should be adjusted according to the Czech norm as follows: Articles in journal - author's surname and initials, title of the article, international abbreviation of the journal, volume, pages and the year of issue. For instance: Motoki, D. S., Altobelli, D. E., Mulliken, J. B.: Enophthalmos following orbital transposition for craniofacial malformations. Plast. Reconstr. Surg., 91: 416 - 422, 1993.

Books and monographs: the name of authors, title of publication, place of issue, publisher, year of issue and - maybe - also the page from which the quotation was taken. For instance: Burian, F.: Surgery of Cleft. Praha, SZdN 1954. Book chapters: Fára, M.: Anatomy of unilateral and bilateral cleft lip. In Bardach, J., Morris, H. L., eds. Multidisciplinary Management of Cleft Lip and Palate. Philadelphia, W. B. Saunders, 1990: 134 - 144. The abbreviation et al. is not acceptable in the reference section and each reference must begin on a new line.

Manuscripts which do not comply with these requirements cannot be published. The editorial board reserves the right to suggest the publication of author's article in the form of an annotation, make corrections, or on account of comments made by the reviewers, return the manuscript to the author for redrafting. The papers must be sent to the editor in their final formulation. The galley proofs are done by the author, but no essential changes are permitted. The authors of original papers will receive issue of the Journal and 20 reprints free of charge and without special order. Additional reprints are available at the address given below.

For those who prefer to submit Graphs printed on a laser printer:

Please do not use grid in your Graphs. Remember that Graphs are scanned and often reproduced in a smaller size than 1 : 1. Increased density of dots then makes grids unclear and „stainy". Use black and white areas or black lining.

For those who prefer to submit their papers on a diskette:

Both 3 1/2" and 5 1/4" diskettes are accepted. Use WORD (DOS) or WINWORD text editor, version 5.0 and higher, only. In WINWORD, cancel automatic SAVE before you start writing. Write doublespaced (max. 30 lines per page), do not underline, do not change typesizes, do not indent. New paragraph should be marked only by ENTER on a previous line. Do not create Tables, write them only as a text. Each diskette must be prevented from accidental erasing and accompanied by a printed text, in which you can underline and mark the desired shape of Tables. Due to increasing postage, diskettes are not returned to the authors.

For those who wish to submit colour photodocumentation:

Use preferably photographs, sharp, of high quality only, optimal size 10 x15 cm, max. 21 x 15 cm. Slides are also accepted. Slides must be marked with the name of the author, the arrow indicating the top side and the Fig. number. Graphs in colours are not accepted in any form. Colour documentation is reproduced free of charge.

You can order your extra reprints at the usual prices and of requested amount at the folowing address:

Czech Medical Association JEP
Publishing Division
Sokolská 31, 120 26 Prague 2, Czech Republic
Fax +4202-249 11 420
E-mail: nts@iol.cz

Abeceda mokré terapie

HARTMANN

HARTMANN-Rico

Nová éra v hojení ran: TenderWet, Hydrosorb, Sorbalgon

HARTMANN-RICO A.S., Masarykovo nám. 77, 664 71 Veverská Bítýška, INFORMACE 0800-100 333