

Clinical outcomes of absorbable plates (hydroxyapatite-poly-l-lactide composites) for phalangeal fractures – case reports

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Summary

We report two cases of the basal phalanx fractures of the thumb treated with absorbable mesh plates. In both cases, the mesh plates specifically tailored for each fracture were effective in obtaining bone union and healing. We conclude that absorbable mesh plates could be a practical option for phalangeal fractures, especially where proprietary pre-molded metallic plates do not neatly fit the reduced fracture area.

Key words

phalangeal fracture – absorbable plate – open fracture – internal fixation – flexible

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Introduction

The generally accepted processes for the treatment of severe comminuted unstable phalangeal fractures or non-union fractures firstly include anatomical reduction and then stabilization by open procedures [1]. However, it is recognized that it is not always easy to maintain the ideal anatomically reduced configuration by the use of conventional metallic plates [2–4]. Conventional metallic plates are more frequently used than Kirshner wires because of their rigid fixation, which facilitates early motion. However, they have also disadvantages; their “ready-made” design does not fit all reduced fractures. Further, they are “palpable” beneath the skin and this sometimes results in discomfort or adhesion of the surrounding tissues necessitating a second operation to remove the plate. Contrary to this, hydroxyapatite and poly-L-lactate composite (μ -HA/

PLLA) absorbable mesh plates present fundamental advantages: they are flexible and easily shaped to adjust neatly to the reduced fractures during surgery. Also, they generally do not require a secondary procedure to remove the plate basically because they are “absorbable”, albeit over a long time frame. Moreover, they not only have the biomechanical strength equal to or greater than that of titanium plates [5] but they also promote replacement with a new bone [6]. For these reasons, absorbable mesh plates have been widely used in oral, maxillofacial and orthopedic surgeries [7–9]. We report two cases of fractures of the basal phalanx of the thumb treated with absorbable mesh plates.

Description of the cases

We used a mesh plate (thickness 0.7 mm) consisting of a mix of poly-L-lactide (PLLA) and micro-crystalline hy-

droxyapatite (μ -HA) that are described as an absorbable product, characteristically when used for osteosynthesis (SuperFixorb MX40 Mesh; Teijin Medical Technologies Co., LTD., Osaka, Japan). After the reduction of the fractures, the absorbable mesh plates were shaped to adjust the reduced fractures with surgical scissors and subsequently dipped into sterilized hot water (68 °C) to soften. This allowed the plates to be molded three-dimensionally to fit the reduced fractures. Then, the absorbable mesh plates were placed and fixed with absorbable 2.0 mm screws consisting of the same materials as the mesh plates.

Case 1

A 22-year-old man suffered a machine crush to his left non-dominant hand at work. The open fracture of the basal phalanx of the thumb was diagnosed and the bone fixation by crossed Kirsch-

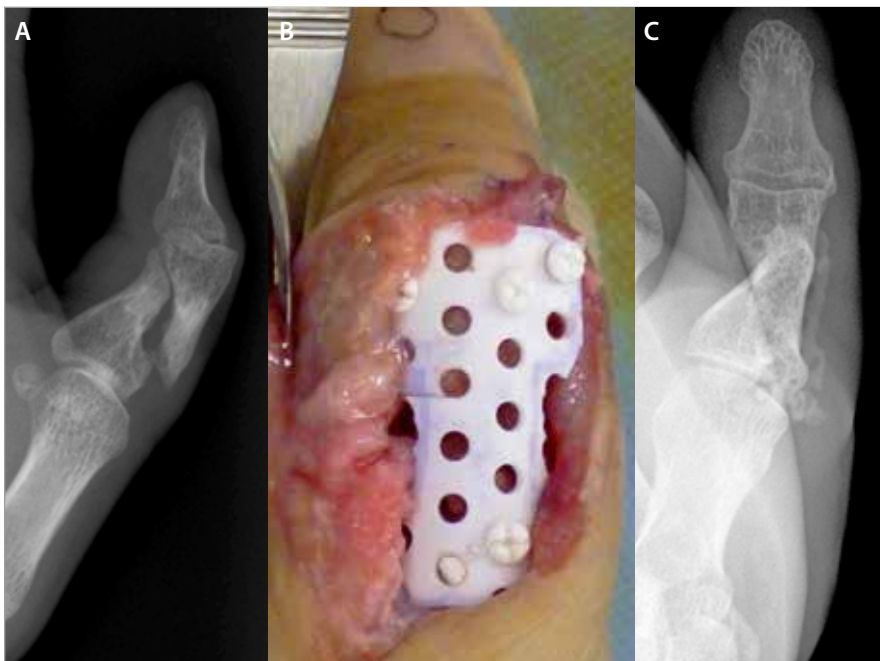


Fig. 1. Radiographic and macroscopic evaluation (case 1). A) Preoperative X-ray (posterior-anterior view); B) operative finding; C) postoperative X-ray (posterior-anterior view) 6 months after mesh plate fixation.

ner wires was performed initially. Six months postoperatively, the patient was referred to us as the bone had not united (Fig. 1A). We performed the re-osteosynthesis using an absorbable mesh plate combined with an iliac bone graft

(Fig. 1B). The mesh plates were trimmed to cover the entire fracture by making wrap around the flaps before softening. Bone healing was achieved at 3 months postoperatively as shown radiographically (Fig. 1C). However, 5 months post-

operatively, skin irritation and swelling around the wound were presenting (Fig. 2A). Even though an infection was excluded by blood tests and tissue culture, we chose to open the site to surgically rectify the problem. Intraoperatively, no active inflammatory synovial tissue was observed (Fig. 2B), while the remaining undissolved mesh plate (> 50%) apparently irritated the skin above, so the residue was removed. This was successful and no further symptoms persisted. We further noted that histological examination showed no foreign body granuloma reaction in the tissues around the mesh plate (Fig. 2C). At 7 months postoperatively, a total active range of motion (TAM) of 50° was present at the metaphalangeal (MP) joint and at 10° at the interphalangeal (IP) joint. The power grip with a Smedley's dynamometer (Muranaka Medical Instruments Co LTD, Japan) was equivalent to 30 vs. 45 kg on the contralateral side.

Case 2

A 46-year-old male manual worker crushed his left hand under an iron plate



Fig. 2. Photographs of the left thumb of a 22-year-old patient (case 1). A) Macroscopic view; B) operative finding; C) histological finding.

at work. An open fracture of the basal phalanx of the left thumb was presented and bone fixation with two transverse K-wires was performed initially (Fig. 3A). The patient was referred to our hospital 4 days postoperatively for further treatment. We performed re-osteosynthesis using an absorbable mesh plate combined with a bone graft 18 days after the initial operation (Fig. 3B). Satisfactory bone healing was confirmed by radiography at 3 months after the second operation. No irritation of the skin was observed, with final follow-up at 55 months (Fig. 3C). The MP joint had a measured TAM of 20° and a thumb-index key pinch movement. The grip strength with a Smedley's dynamometer was equivalent to 43 vs. 52 kg on the contralateral side. X-rays of the site showed some residue of the plate still remaining; however, this was uneventful (Fig. 3C).

Discussion

Absorbable mesh plates have been used for osteosynthesis of fractures of the hand, osteosynthesis in port-access cardiac surgery and fixation in Le Fort I osteotomy to date [5,10,11]. The μ-HA / PLLA composite provides several advantages over metallic implants, such as early osteoinductivity and bioactivity promoting final bone union. Furthermore, the mechanical strength of the absorbable mesh plate was higher than the conventional PLLA implants without HA [12] and further enhanced by bending the mesh plate. In addition, they are



Fig. 3. Radiographic evaluation (case 2). A) Preoperative X-ray (posterior-anterior view), note the malalignment; B) postoperative X-ray (posterior-anterior view), note the restoration of the anatomical axis; C) postoperative X-ray (posterior-anterior view) at a 5-year follow-up.

flexible, radiolucent, MRI compatible and they do not require secondary hardware removal. In our cases, the mesh plate maintained rigid mobilization until bone healing.

Previously, Jupiter et al reported that the plate or screw fixation for the non-union of metacarpal and phalanges fractures united at a mean of 11.4 weeks after the surgery [13]. Although their report included metacarpal and other phalanges, the period for bone union in our cases was comparable to their report. Patankar et al utilized threaded external fixators for the atrophic nonunion of the proximal phalanx of the thumb and reported that they united within 5 months [14]. Our cases showed bone healing within 3 months, which was shorter than in their report. We speculatively attri-

bute this to the fixation strength of the mesh plates.

Mesh plates have advantages compared to metallic implants. Firstly, they can be shaped to fit the anatomically reduced fractures and their varieties of the screw holes provide more choices than ready-made metal plate holes. Therefore, to insert screws around the metaphyseal and juxta-articular region or comminuted fractures, mesh plates are advantageous.

Secondly, they are thinner (0.7 mm thickness) than metallic plates of 1.0 mm thickness (VariAx hand locking system, Stryker, Freiberg, Germany) and of 0.75 mm thickness (Variable angle locking hand system, Depuy Synthes, Oberdorf, Switzerland); therefore, the associated risk of soft tissue irritation may be lower.

Tab. 1. Active range of motion and grip strength at final follow-up period.

Case	Age (y.o.)	Affected side (right/left)	Bone healing	Metacarpophalangeal joint ROM (extension/flexion)	Interphalangeal joint ROM (extension/flexion)	Grip strength, (kg)	Follow-up period	Remaining composites in the X-ray image	Foreign body reaction
1	22	L	3 m	0/50°	-40/50°	30 (45)	2 y 3 m	(+)	(-)
2	46	L	3 m	-20/40°	-15/15°	52 (43)	5 y	(+)	(-)

m – months, ROM – range of motion, y – years, y.o. – year of operation

However, in case 1, the residual mesh plate caused irritation of the skin and needed to be removed. To avoid skin irritation, we suggest evaluation of the soft tissue condition before surgery. It should be noted that the size of the mesh plate is important as the total bio-absorption of the mesh plates requires considerable time. Kosugi et al reported the process of total bio-absorption required approximately 8 years in metacarpal fractures even though the speed of absorption depends on the location of surgical intervention [15].

We report here that absorbable mesh plate is practical for repairs of fractures to the basal phalanx of the thumb. Absorbable mesh plates could be a surgical alternative to treat fractures of the phalanx if an appropriate metallic plate is unavailable.

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