Transient bone resorption following finger replantation: a report of 3 cases

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Abstract Radiographic changes consisting of alterations in mineral content, osteopaenia or destructive neuropathy that occur following successful finger replantation have already been described. We report our experience about four fingers in three individuals in whom bone changes developed in the first three months postoperatively with complete “restitution ad integrum”.

Three patients, 21-49 years old (average 36 years) sustained a clean-cut amputation of four fingers. The first patient had an amputation at the base of the middle phalanx of the index finger and the second patient at the base of the proximal phalanx of the ring finger. The third had an amputation at the base of the first metacarpal bone and the proximal phalanx of the small finger in a five finger amputation. In the first case, two dorsal veins and two palmar digital arteries and nerves were repaired. In the second case, one palmar artery and one dorsal vein were reanastomosed. In the third case at the thumb, two dorsal veins and two palmar digital arteries and nerves were reconstructed. At the small finger, one dorsal vein, one palmar digital artery and two digital nerves were reconstructed. Bone fixation was achieved with two and three K-wires or tension-band wiring. Replantation was successful in all cases. Three weeks after replantation, the X-rays showed rapid development of osteopaenia in the juxtaarticular region and metaphyses of the bone. These changes were followed by subperiosteal, intracortical and endosteal bone resorption. No further surgical procedures or splintage were needed and hand therapy was not discontinued. At 10-13 weeks (average 12 weeks) postoperatively, the X-rays showed a complete recovery with new periosteal bone formation.

We suggest that the radiographic changes after finger replantation are transient, first evident subperiosteally and progressing centrally. They may reflect small-vessel compromise and microinfarction and transient hyperemia secondary to neurovascular damage or to sympathetic progressive recovery.

Keywords: Fingers; Replantation; Bone resorption

Advances in modern microsurgery started in 1962 with the first replantation of an amputated limb by Malt and McKhann, followed by the first finger replantation by Komatsu and Tamai. Osteosynthesis should be simple and efficient. Stable fixation without compromising the skin or violating the joint is important because this allows early rehabilitation, which translates into better functional recovery. Generally, the method of fixation depends on the site of amputation. Comparisons between fixation techniques reveal that interosseous wiring has the lowest rate of non-union and complication. Bony problems are common, and they occur in 50% of all replantations. Radiographic changes like alterations in mineral content or osteopaenia that occurs following successful finger replantation have already been described in a few reports but they are just descriptive and have not mentioned any therapeutic solution. We reported our experience of 4 fingers in 3 individuals in whom bony changes developed in the first 3 months postoperatively with complete functional recovery.

CASE REPORT

Case one

A 39-year-old female, non-smoker, underwent replantation of the dominant index finger following traumatic amputation in a gold cutting machine. Preoperative radiographs (Figure 1A) demonstrated a clean cut...
amputation at the base of the middle phalanx, distal to the insertion of the flexor digitorum sublimis (FDS) tendon. Intraoperatively two dorsal veins and both the radial and ulnar palmar digital arteries were reanastomosed. Both the digital nerves were repaired. Bony fixation was achieved with two K-wires. No bone shortening was needed. The initial postoperative recovery was uncomplicated.

Radiography of the finger performed for routine follow-up at three (Figure 1B) and six weeks showed rapid development of osteopaenia in the juxtaarticular region and metaphyses of the bone distal to the bone fixation. No clinical problems such as swelling or focal pain were detectable. These changes were followed by subperiosteal, intracortical and endosteal bone resorption.

Thirteen weeks after the operation, radiographs showed an increase of mineral content, with periosteal reaction at the site of replantation and callus formation (Figure 1C). At 14 weeks hardware removal was performed.

The subsequent sensory functional recovery was S3+ according to Dellon et al’s classification. Based on the classification of the American Society for Surgery of the Hand (ASSH), the active range of motion (AROM) was defined as good, equivalent to 185°. The patient was able to go back to her previous work on day 124 postoperatively.

Case two
A 49-year-old male, non-smoker, underwent replantation of the dominant ring finger following traumatic amputation with a circular saw. Initial radiographs (Figure 2A) demonstrated a clean cut amputation at the base of the proximal phalanx, proximal to the insertion of the FDS tendon. Intraoperatively one dorsal vein and one palmar digital artery were reanastomosed. Bone fixation was achieved with three K-wires. No bony shortening was needed and the digital nerves were found to be intact.

Associated injuries included small finger amputation at the proximal interphalangeal (PIP) joint with primary closure of the amputation stump and middle finger metacarpal neck fracture that required a metacarpophalangeal (MP) pyrocarbon arthroplasty. The initial postoperative recovery was uncomplicated.

Follow-up radiographs at three weeks and five weeks (Figure 2B) showed rapid development of osteopaenia in the juxtaarticular region and metaphyses of the bone, especially on the radial side of the base of the proximal phalanx distal to the site of bone fixation. No clinical problems such as swelling or increased pain were detectable. These changes were followed by subperiosteal, intracortical and endosteal bone resorption.

Ten weeks after the operation, radiographs show an increase of mineral content, with periosteal reaction at the site of replantation and callus formation at 10 and 12 weeks (Figure 2C). At 12 weeks hardware removal was performed.

The subsequent recovery of sensory function was good, being S4 according to Dellon’s classification. According to the classification of ASSH, the AROM was defined as poor, equivalent to 94°. The patient was able to go back to the previous work 240 days after operation.

Case three
A 21-year-old male, smoker, underwent replantation following five finger amputation of the dominant hand with a mitre saw. The replantation of thumb and small finger are the matter of discussion in this study. The amputation was through the thumb metacarpal bone and the proximal phalanx of the little finger.

Initial radiographs (Figure 3A) demonstrated a traumatic clean cut at the middle third of the first metacarpal bone and the proximal phalanx of the small finger. For the thumb, two dorsal vein grafts were needed to restore the backflow. The radial palmar digital artery was reanastomosed and the ulnar one was reconstructed via a vein graft, in an end-to-side fashion from the dorsal branch of the radial artery. The two digital nerves were repaired using collagen tubes (NeuraGen® Integra LifeSciences, USA). Bone fixation was achieved with tension band wiring. For the small finger, one dorsal vein, one palmar artery and two digital nerves were repaired. Bone fixation was achieved with tension band wiring.

Radiographs of the hand taken for routine follow-up at 3 weeks and 6 weeks (Figure 3B) showed rapid development of osteopaenia in the juxtaarticular region and metaphyses of the base of the first metacarpal bone
and proximal phalanx of the small finger. These changes were followed by subperiosteal, intracortical and endosteal bone resorption. Thirteen weeks after operation, the radiographs (Figure 3C) showed an increase of mineral content, with periosteal reaction at the site of replantation and callus formation. At week 4 inadvertent hardware removal was performed by the patient himself.

Associated injuries included index, middle and ring finger amputations. The level of the amputation was located at the second metacarpal bone and the distal third of the proximal phalanx of the middle and ring fingers. Intraoperatively, at the index finger, one common digital artery in the second web-space and the radial digital nerve were repaired. Bone fixation was achieved with tension band-wiring of the second metacarpal bone. At the middle finger, one common digital artery and both palmar digital nerves were repaired. PIP joint fusion was performed with tension band wiring. At the ring finger, one dorsal vein, one palmar artery and both palmar digital nerves were reconstructed. Bone fixation was achieved with tension band wiring. No bone resorption after finger replantation was detectable in the index, middle or ring fingers.

The initial postoperative recovery was uncomplicated and the subsequent recovery of sensory function was S2, according to Dellon et al’s classification. Based on ASSH classification, the AROM was defined as poor, equivalent to 85° at the thumb and 61° at the small finger.

**DISCUSSION**

Only a few reports can be found in the scientific literature regarding bone changes after replantation surgery. They are all just descriptive with the aim of adding a pathophysiologic theory but no therapeutic strategy to prevent any further complication, i.e. bone loosening, delayed consolidation and finger stiffness, is given. Moreover they do not answer the question: should we immobilize a replanted finger with transient bone resorption or not?

In 1983, Kattapuram and Philips reported a series of 62 replantations in 25 patients. He observed a rapid decrease of the mineral content of the distal bony fragment for 10 weeks. This was followed by a gradual increase in the mineral content over time, reaching the maximum at 25 weeks. The periosteal reaction at the site of replantation reached the maximum at 10 weeks and then gradually decreased with time. Callus formation increased with time, being mature by 15 to 20 weeks in most cases. A loose correlation was noted between the amount of surgically created bony shortening and the time to complete union. Deviations from the expected aforementioned pattern on the radiographs could indicate the presence of a complication. No detail is given about the therapy.

In 1984, Guerra et al reported a series of clinical records and radiographs in 45 patients who had undergone replantation of part or a total hand. In three patients, destructive changes were observed, consisting of bony fragmentation, spiculation, and cystic or erosive lesions. In two out of three patients, sensory recovery was good and distal digital temperatures “nearly” normal. He proposed a correlation between joint abnormalities and osteonecrosis or neuroarthropathy. No detail is given about the therapy.

In 1992, Jackson and his colleagues reported a series of 5 limb reimplantations, 4 of the upper limb. He examined in detail the postoperative radiographic appearances. He found a rapid development of osteopaenia in the juxtaarticular regions and metaphyses of the tubular bones of the hand, followed by diaphyseal cortical bone loss with subperiosteal, intracortical and endosteal bone resorption. Juxtaarticular erosions developed at the margins of the small joints in the hand in all cases. He suggested that the radiographic changes observed after upper limb reimplantation reflect regional hyperemia secondary to neurovascular damage. No detail is given about the therapy.

As for the former theory small-vessel compromise and microinfarction may have occurred in the absence of osteosclerosis generating an ischemia and subsequent infarction in the subchondral region. As for the latter theory it has been demonstrated that bone tissue is densely innervated and there is increasing evidence for neural control of bone metabolism. Human osteoblastic as well as osteoclastic cells are equipped with adrenergic and neuuropeptide receptors and they constitutively express diffusible axon guidance molecules that are known to function as chemoattractant and/or chemorepellent for growing nerve fibres.
Figure 1. A 39-year-old right-handed woman, with an index finger amputation at the base of the intermediate phalanx distal to FDS insertion. (A) Preoperative and (B) postoperative radiographs at three weeks and (C) 13 weeks. Hardware removal was performed at 14 weeks. 

Figure 2. A 49-year-old right-handed man, with a ring finger amputation at the base of the proximal phalanx. (A) Preoperative, (B) postoperative radiographs at 5 weeks and (C) 12 weeks. Periosteal reaction at the site of replantation and callus formation were noted at 12 weeks. 

Figure 3. A 21-year-old right-handed man, with an amputation of the first metacarpal bone and proximal phalanx of the little finger in a five finger amputation. (A) Preoperative, (B) post-operative radiographs at six weeks and (C) 13 weeks.
It is possible that local variation in sympathetic nervous activity can cause bone loss via an increase in bone resorption and a decrease in bone formation. Moreover the sympathetic innervation may be reduced when arteries and nerves are severely contused or inadequately repaired following amputation. The damage of sympathetic nerves may be severe enough to initiate the neurovascular reflex leading to aggressive bone resorption and destructive articular changes.

In our case series, no correlation was found regarding the number of anastomosed vessels and the extent of bone resorption or secondary joint destruction. In two of the replanted fingers, there were both digital arteries anastomosed, whereas the other two had only one artery and one vein reconstructed, therefore no direct correlation can be found. Recent literature holds no definite answer to this matter, mainly because of the small number of reported cases. Therefore a larger case series would be needed to draw any conclusion in this regard.

Another theory following studies by Abu-Amer depends on the secretion of pro-inflammatory cytokines that enhance osteoclast development and activity. A new pro-osteoclastic signalling pathway is transmitted by TNF via its type-1 receptor (TNFR-1) in osteoclast precursor cells.

From our experience, bone resorption in finger replantation is a transient condition with no need of immobilization or surgical therapy with bone substitutes.

Conflict of interest

No benefits in any form have been received or will be received from a commercial party related directly and indirectly to the subject of this article.

REFERENCES


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