Pathoanatomy and treatment modifications of metacarpophalangeal joint locking of the thumb

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Abstract
Ten patients with metacarpophalangeal joint locking of the thumb were studied. Three of them underwent surgical release. During surgery, it was found that the radial sesamoid was seated in a cartilage defect on the volar aspect of the metacarpal head. It appeared that the defect was created by the proximal edge of sesamoid. When the abductor pollicis brevis and flexor pollicis brevis muscles were partially detached from their insertion at the base of the proximal phalanx, the locking could be successfully released. We hypothesize the mechanism of the metacarpophalangeal joint locking of the thumb in our cases was a hyperextension injury that displaced the radial sesamoid distally and radially. In turn, the sesamoid’s pointed proximal edge wore a groove in the cartilage on the metacarpal head, and under abductor pollicis brevis and flexor pollicis brevis tension, the radial sesamoid was locked into the cartilage defect; thereby causing locking of the joint.

Keywords
Locking, metacarpophalangeal joint, pathoanatomy, thumb, treatment

Introduction
Metacarpophalangeal joint (MCPJ) locking of the thumb is relatively rare. Most cases have been reported in Japan (Ishizuki et al., 1994; Kojima et al., 1979; Tsuge and Watari, 1974; Yamanaka et al., 1985). The rarity of this type of injury could be attributed to the reasoning that this type of locking requires a relatively weak force and that a stronger force that usually occurs in hyperextension thumb injuries would have led to a MCPJ dislocation (Yamanaka et al., 1985). Patients normally present after a relatively weak force hyperextension injury of the thumb, with the thumb locked in mild to moderate hyperextension and the patient finding it difficult to passively or actively extend or flex the MCPJ with pain over the volar aspect of the joint (Tsuge and Watari, 1974).

Although its causes are well discussed, it remains controversial because in the laboratory setting, actual MCPJ locking of the thumb could not be reproduced (Desai and Morgan, 1991). The previously mentioned causes of locking include volar plate incarcerated into the MCPJ, sesamoid entrapment, locked trigger thumb, fracture fragment or loose body entrapment and morphological abnormality, such as bony prominence of the first metacarpal head (Desai and Morgan, 1991; Hirata et al., 2006; Kojima et al., 1979; Ueda et al., 2006). But our intraoperative findings show that the radial sesamoid was supinated to the radial side of the first metacarpal head, and its pointed proximal edge had worn down on the cartilage surface of the metacarpal head creating a groove defect. The sesamoid was found seated in the groove. The aforementioned intraoperative findings suggest an additional causal mechanism of locking of the MCPJ in the thumb. In light of this, subsequent treatment was modified and gave a successful outcome.

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Methods and results

Following institutional review ethical board approval, we identified ten patients who were presented during the past 5 years because of the MCPJ locking of the thumb. Informed consent was obtained from each patient. Seven of those 10 patients had successful closed reduction, but the remaining three patients had unsuccessful closed reduction and underwent surgical treatment.

These three remaining cases are described as follows.

Case 1

A 23-year-old right-hand dominant policeman sustained a hyperextension injury of his MCPJ of his right thumb while apprehending a suspect. After the injury, he experienced pain, swelling, active flexion dysfunction of his thumb MCPJ and found the joint locked in a hyperextension position. He presented on the same day to our department where clinical examination revealed a mild hyperextension deformity of the MCPJ and slight flexion at the interphalangeal joint (IPJ). The MCPJ could not be flexed actively, but it could be flexed to some extent passively (Figure 1). The active range of motion (ROM) of the MCPJ was between 25° to 35° of hyperextension, while the passive ROM was between 30° of flexion and 35° of hyperextension. The IPJ could be actively flexed and extended. The thumb MCPJ was moderately swollen with pain on palpation of the radial aspect of the joint. There was no significant collateral ligament instability compared with the contralateral side.

On lateral radiograph of the injured thumb, the MCPJ was in hyperextension. Both the radial and ulnar sesamoids had displaced distally, while the radial sesamoid was more distal and there was no clear joint space between the radial sesamoid and the metacarpal head (Figure 2).

Three-dimensional computed tomography (3D-CT) showed that there was a normal joint space between the ulnar sesamoid and the volar aspect of the metacarpal head, while the radial sesamoid was seen vertically riding on the metacarpal head. The sagittal CT scan showed that there was loss of joint space at the articulation between the radial sesamoid and the metacarpal head, and the radial sesamoid was surrounded by the soft tissues except at its proximal edge (Figure 3).

After unsuccessful closed reduction, open reduction was performed on the second day of the injury. A radial mid-lateral approach was used. The abductor pollicis brevis and flexor pollicis brevis muscles were partially detached from their insertion at the base of the proximal phalanx, which was distal to the radial sesamoid. Then the radial sesamoid was found to be seated on the metacarpal head vertically. The sesamoid was reduced successfully after partial release of its distal muscle insertion, after which locking of the MCPJ was relieved immediately. After the sesamoid was reduced, there was a small
groove-like cartilage defect, which was engraved by the pointed proximal edge of the radial sesamoid. When the MCPJ was flexed and extended passively, the small cartilage defect was never covered by the base of the proximal phalanx (Figure 4). This suggests that obstruction of the locked sesamoid may

Figure 2. Lateral (A) and anteroposterior (B) radiographs before release showed hyperextension of the MCPJ. The thick arrow marks the ulnar sesamoid that was displaced slightly distally. The thin arrows mark the pointed proximal edge of the radial sesamoid that was partially overlapping with the image of the metacarpal head.

Figure 3. The 3D-CT showed the radial sesamoid was seated on the metacarpal head. (A) Volar view of the 3D-CT showed that there still existed an interval between ulnar sesamoid and the metacarpal head, while the interval between radial sesamoid and the metacarpal head disappeared. It inferred that there was cartilage damage between radial sesamoid and the metacarpal head. (B) Lateral view of the 3D-CT picture showed that the radial sesamoid was seated on the metacarpal head with its proximal edge contacted with the metacarpal head. (C) The sagittal CT scan of the injured thumb showed that there was no interval between the radial sesamoid (thin arrow) and the metacarpal head (thick arrow), and the thenar muscles surrounded the sesamoid except its proximal edge.
not be the only cause of the MCPJ locking. After operation, an extension-block splint was used for 3 weeks. The patient was encouraged to start early active ROM of the MCPJ with the splint on the second postoperative day.

The patient was followed up for 6 months at which there was no recurrence of the locking and instability of the MCPJ, the patient had returned to his pre-injury occupation as a police officer and did not have any pain of the injured MCPJ. Both passive and active ROM of the MCPJ was 55° of flexion and 0° of extension. There was no active hyperextension observed for the patient postoperatively. Abduction and thumb opposition of the injured thumb had almost recovered to pre-injury status. The postoperative radiographs revealed no abnormality of the MCPJ (Figure 5). The patient was satisfied with the outcome.

Case 2

A 30-year-old male right-hand dominant office worker fell on his extended and abducted left thumb. He found that his MCPJ of the thumb was fixed in a hyperextended position. He presented to his local hospital where he was initially diagnosed with suspected subluxation of the MCPJ and was treated conservatively in a fixed flexion splint. Unfortunately, the patient’s deformity persisted and 2 weeks later he was referred to our department. The findings of X-ray and CT findings were similar to those of Case 1. The active ROM of the MCPJ was between 30° to 35° of hyperextension, while the passive ROM was between 25° of flexion and 35° of hyperextension. After unsuccessful closed reduction, 19 days after the injury, he underwent open reduction. The surgical procedure and findings were similar with those of Case 1. The only difference was that the groove-like cartilage defect on the metacarpal head was much narrower than that of the Case 1 (Figure 6).

The postoperational splint and exercise methods were the same with the former patient. He was followed up for 5 months. Both passive and active ROM of the MCPJ at the end of the follow-up was 40° of flexion and 0° of extension. He felt no pain and returned to his normal work and activities of daily living. The postoperative radiographs showed that the sesamoid positions of the injured MCPJ were normal. The patient was satisfied with his treatment.

Case 3

A 29-year-old right-hand dominant male manual worker experienced pain and disturbance of flexion following hyperextension of the MCPJ of the right thumb sustained after falling off a bicycle. He was sent to our clinic immediately. It was found that his MCPJ of the right thumb was slightly hyperextended.
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The IPJ was in a slightly flexed position. The active ROM of the MCPJ was 27° to 32° of hyperextension, while the passive ROM was 25° of flexion and 35° of hyperextension. X-ray and CT revealed similar findings to that of Case 1. After an unsuccessful closed reduction under axillary block anaesthesia, open reduction was performed. The operative method and the intraoperative findings were the same as in Case 1. On the second day postoperation, the patient was encouraged to start early active ROM of the MCPJ with an extension-block splint for 3 weeks. He was followed up for 3 months. At the end of the follow-up, both passive and active ROM of the MCPJ was between -5° of extension to 55° of flexion. He felt no pain on the MCPJ and returned to his normal work and activities of daily living. The postoperative radiographs revealed no abnormality of the MCPJ. The patient was satisfied with the treatment.

A summary of the patients’ characteristics is shown in Table 1.

Discussion

MCPJ locking of the thumb is relatively rare, and possible causal mechanisms have been discussed extensively in the literature. Some authors suggest that sesamoid entrapment was the major cause of locking [Desai and Morgan, 1991; Tsuge and Watari, 1974]. But in our three cases, this would not explain the fact that passive flexion of the MCPJ was possible. This suggests that, although displaced, the radial sesamoid had not blocked the movement of the base of the proximal phalanx.

Figure 5. Lateral [A] and anteroposterior [B] radiographs taken 2 months after operation showed that the position of both sesamoids of the thumb MCPJ were almost normal.

Figure 6. The black arrow marks a quite narrow cartilage defect that was found in another case of the MCPJ locking of the thumb. The defect was so narrow that it was hardly possible to be caused by ligament bundle.

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Some authors suggest that sesamoid entrapment was a block to joint motion (Ishizuki et al., 1994; Tsuge and Watari, 1974; Yamanaka et al., 1985). However, in our three cases, the fact that passive flexion of the MCP J was possible suggests that the displaced radial sesamoid had not impeded movement at the base of the proximal phalanx. Our findings suggest that another reasonable explanation could be that the radial sesamoid was moved and locked at the distal and radial side of the metacarpal head. This explanation was verified by our surgical findings and the pre-operative 3D-CT scans.

According to our clinical findings and relative anatomical study, we suggest that an additional causal mechanism of thumb MCP J locking:

1. A high energy hyperextension injury to the MCPJ of the thumb.
2. The radial sesamoid moved distally and laterally to the top of the metacarpal head.
3. Because of the blocking of the base of proximal phalanx and the increasing tension of the abductor pollicis brevis and flexor pollicis brevis muscles, the radial sesamoid is supinated along the axial plane to the radial side of the MCPJ. At the same time the sesamoid also rotates 90° from a vertical to a horizontal orientation and its proximal edge is dislodged from the tendon in a counter-clockwise direction.
4. The isolated sharp pointed proximal edge of the radial sesamoid engraves a groove on the cartilage of the metacarpal head and subsequently the sesamoid is trapped in the groove.
5. Because the radial sesamoid is embedded in the abductor pollicis brevis and flexor pollicis brevis muscles, the proximal part of the muscles remain taut and extended, while their distal part will become rather lax with the sesamoid blocked on the metacarpal head. As the abductor pollicis brevis contracts, there is no proximal excursion of this muscle and its tendon, thus there will be no tension spread to the base of the proximal phalanx, leading to no flexion of the MCPJ. It is also important to consider that the displaced sesamoid no longer produces a flexion force across the MCPJ, and in its embedded position, there is an extension moment, similar to the mechanisms in the lateral bands of the proximal IPJs. A combination of the above factors would mean the MCPJ should stay in a position of slight hyperextension with the tension of the extensors (Figure 7).

Since the radial sesamoid is embedded in the tendon of the abductor pollicis brevis and flexor pollicis brevis muscles, it can be difficult to uncover the pointedness of its proximal edge. Furthermore, it is rare for the pointed proximal edge to embed and block on the metacarpal head. There may be a correlation between the occurrence of the MCPJ locking and volar-dorsal length of the sesamoid, in terms that patients with more pointed thumb sesamoids may be at higher risk for developing entrapment within the MCPJ, however additional studies would be needed to investigate this hypothesized correlation further. The tension of the abductor pollicis brevis and flexor pollicis brevis is essential in maintaining the blocking of the sesamoid on the metacarpal head, and also maintaining the tension of the extensor pollicis brevis that leads to hyperextension of the MCPJ. Therefore, it may not be possible to reproduce actual locking of the thumb MCPJ in the laboratory setting.
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Figure 7. The mechanism diagram of the MCPJ locking of the thumb. The radial sesamoid moves distally and laterally to the top of the metacarpal head under a hyperextension impact. Its proximal edge is blocked in a cartilage defect on the metacarpal head, which is engraved by the sesamoid itself. Because the radial sesamoid is embedded in the abductor pollicis brevis and flexor pollicis brevis muscles, the proximal part of the muscles will be taut and in extension, while the distal part will become rather lax with the sesamoid blocked on the metacarpal head. Thus, there will be no tension spread to the base of the proximal phalanx. So the MCPJ will stay in a position of slight hyperextension with the tension of the extensors.

Figure 8. A patient demonstrated that his MCPJ blocking of the thumb was released when he tried to cut his nails with a nail-clipper pre-operatively.

without any muscle tension (Desai and Morgan, 1991). Since the proximal edge blocking and the tension of the abductor pollicis brevis and flexor pollicis brevis muscles are two important factors for the MCPJ locking, the treatment methods can be improved to be more efficient. For the close reduction manoeuvres we designed two methods. The first one is a passive reduction manoeuvre. It is similar to the classical reduction manoeuvres. Under local anaesthesia, the proximal phalanx is further extended and slightly ulnar deviated so that the sesamoid can be pulled out of the groove-like depression. The second one is an active reduction manoeuvre. The patient is encouraged to do thumb abduction and flexion of MCPJ repeatedly. The manoeuvre mimics the action of holding and pressing a nail-cutter (Figure 8). By this way, the abductor pollicis brevis and flexor pollicis brevis muscles may pull the radial sesamoid out of the groove. This method was found by chance. One of our patients reported that his MCPJ locking was released when he cut his nail before operation. After that we tried this method successfully in other two patients; and the locking was released in four patients with the first manoeuvre.

Intraoperatively, simply cutting the partial insertion of the abductor pollicis brevis and flexor pollicis brevis muscles at the base of the proximal phalanx, or just pulling the muscles proximally, can release the blocking. There is no need to cut the collateral ligament or the accessory collateral ligament. By this way, the stability of the MCPJ can be maintained postoperatively. It is essential to use an extension-block splint postoperatively to prevent recurrence of the sesamoid subluxation and MCPJ locking.

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Conflict of interests
None declared.

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