Correction of a Hyperextension Deformity at the Metacarpophalangeal Joint by Arthroplasty for Osteoarthritis of the Thumb Carpometacarpal Joint Followed by External Fixator: A Case Series

Modified Ilizarov Method for Correction of a Collapsed Thumb Deformity Due to Carpometacarpal Osteoarthritis

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Abstract A hyperextension deformity in the advanced stages of carpometacarpal (CMC) arthritis of the thumb could affect the outcomes of thumb CMC joint arthroplasty. We introduce the interesting approach for treating severely collapsed thumb deformities with gradual distraction and coordinated correction of the MCP and CMC joints by means of external fixators. We divided 8 cases into 3 groups according to the angle of passive flexion of the hyperextended MCP joint: group 1, 10–20°, group 2a, 20–40°, and group 2b, >40°, respectively. We first performed CMC arthroplasty with tra-

pezium excision. In group 1, we corrected the MCP hyperextension deformity by manual passive flexion and fixed the joint with an extension block Kirshner wire (K-wire) for 2 months. However, deformities recurred in 2 of 5 cases after removing the K-wire. These patients received corrective percutaneous osteotomy with external fixators at the metacarpal neck. In groups 2a and 2b, we performed CMC arthroplasty and set external fixators at the same time. All cases in groups 1 and 2a have been without recurrence for more than 2 years, while a deformity recurred in group 2b. The results of this small case series encouraged us to propose an interesting approach for collapsed zigzag thumb deformity. Good outcomes with excellent maintenance of active MCP movement and no recurrence are highly anticipated if the hyperextended thumb has no obvious degenerative changes and can be corrected by <40° of passive flexion. Our results also indicate a risk of recurrence associated with extension block by K-wire.

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Introduction

A hyperextension and adduction deformity rarely occurs in the advanced stages of carpometacarpal (CMC) arthritis of

the first metacarpophalangeal (MCP) joint. In severe cases, the thumb collapses into the palm creating a zigzag deformity [1, 2]. Both pre- and postoperative severely collapsed zigzag deformities are difficult to correct, and the hyperextension deformity of the MCP joint could affect the outcome of CMC arthroplasty [1–5]. Previous studies and reviews have recommended choosing treatments according to the angle of passive flexion of the thumb MCP joint and the presence of degenerative changes [1, 6]. Here we report a clinical case series of severely collapsed thumb deformities. We treated 5 patients by CMC arthroplasty followed by gradual distraction and coordinated correction of the MCP and CMC joints and web spaces by means of a modified Ilizarov mini-fixator (IMF), developed by the Russian Ilizarov Scientific Center with some modifications. Our clinical investigation of MCP joint hyperextension deformities was based on the angle of passive flexion of the hyperextensible MCP joint. In this paper, we retrospectively review our clinical results and introduce our new approach based on at least 2 years of follow up.

Materials and Methods

Between 2008 and 2011, 5 patients with MCP joint hyperextension and adduction deformities due to CMC arthritis of their thumbs underwent surgical repair according to the chart shown in Fig. 1. All patients were right-handed and had stage 4 osteoarthritis according to the Eaton and Burton classification (Table 1) [7, 8]. We performed CMC arthroplasty using Kaarela's method, which included trapezium excision and abductor pollicis longus tendon suspension arthroplasty [9], and we applied external fixators to hold the thumb in a proper

position. We then measured the volar tilt (VT) angle (the angle between the perpendicular line to the tangent to the dorsal cortex of the first metacarpal and the line connecting the 2 edges of the first metacarpal proximal facet) on lateral view to show the slope of the first metacarpal base [3, 4]. These factors were clinically evaluated using a visual analogue scale (VAS). Figure 1 shows our treatment method obtained retrospectively. Patients were categorized as follows according to the angle of passive flexion of the hyperextended MCP joint: group 1, 10–20°, group 2a, 20–40°, and group 2b, >40°. In group 1, MCP hyperextension deformities could be flexed passively and manually less than 20° on examination before surgery. Immediately after CMC arthroplasty, we fixed the afflicted joint to <0° with an extension block Kirshner wire (K-wire), and the K-wire was removed after 2 months. MCP hyperextension deformities recurred in 2 of 5 cases. Adduction of a metacarpal was unlikely to be a major cause of recurrence because there was only a small difference between the metacarpal position before and after the treatment with K-wires; this appeared to be due to the severity of contractures or osteoarthritis of the MCP joints itself. In the 2 patients with recurrent deformities, we performed corrective percutaneous osteotomy with IMF at the metacarpal neck. In groups 2a and 2b, CMC arthroplasty and IMF setting were performed at the same time. The postoperative strategy to correct and maintain the posture of the hand is important to obtain a functionally formative hand and to prevent recurrence. For the first 4 weeks after the operation, we pulled the joints by IMF with the proper strength; direct-traction from bones is efficacious and gentle on the soft tissues. This procedure involved the following steps: 1) MCP joint repositioning under distraction; and 2) correcting the first web contracture. The next 2 weeks were

Fig. 1 Schematic of the surgical protocol for the metacarpophalangeal (MCP) joint hyperextension and adduction deformity due to carpometacarpal (CMC) arthritis

Table 1 Patients characteristics and treatment results

	Case No	Gender/ Affected side	Age (years)	Follow-up (years)	MCP degenerative change	VT (o)	VAS before op/ at final	Passive flexion MCP hyperextension		MCP hyperextension at rest		MCP active ROM
								before op	at final	before op	at final	
Group 1	1	f/R	69	2.5	obvious	37	9/5	15	−10	60	15	45
	2	f/R	73	2	obvious	28	7/4	10	−10	50	5	35
Group 2a	3	f/R	78	3	unclear	50	6/2	40	−20	80	−5	30
	4	f/L	60	2	unclear	40	7/3	35	−25	70	0	40
Group 2b	5	f/L	53	3.5	unclear	27	5/2	50	10	85	70	30
Average			67			36	7/3	30	−11	69	17	36

a stabilization period to hold the corrected position of the thumb with an IMF. Active exercise of the affected hand, especially at the interphalangeal joint of the thumb, was permitted immediately after surgery. Finally, subsequent splinting therapy during the day, and more importantly at night, was recommended to keep the corrected position and prevent a recurrence of deformities for 3 months after removal of all apparatuses.

Surgical Technique and Postoperative Management

- 1). *Corrective percutaneous osteotomy with IMF at the metacarpal neck in group 1.* The IMF was adjusted before osteotomy. We cut the metacarpal neck at the adjacent proximal MCP joint by percutaneous technique with small incision using an osteotome and set the affected thumb between the 2 units of the IMF. Each unit was adjusted to hold the hyperextended thumb after correction by 30° or more, according to the condition of recurrence, as shown in Fig. 2e. Active thumb and finger movements were permitted the next day.
- 2). *Correction by IMF immediately after CMC arthroplasty in group 2.* Correction of the contracted, overly extended MCP joint was initiated after long-axis traction provided a sufficient opening in the joint space and reduced the

proximal phalanx as shown in Fig. 3d. The first web contracture was corrected by perpendicular frames after reducing the dorsal dislocation of the proximal phalanx at the MCP joint as shown in Fig. 3d. Active synergic wrist, thumb, and finger movements were started under the supervision of a hand therapist on the third postoperative day. Patients were provided a cock-up wrist splint to wear at rest for 3 weeks.

Results

Table 1 shows the patient data and treatment results. The mean VAS score was 7 preoperatively and 3 at the final follow up and was reduced by 50 % in 3 of the thumbs in groups 2a and 2b. The VT of each group was 27–50° (mean 36°). Only 1 patient, in group 2b, experienced a clinical recurrence within 1 year after surgery. The deformity in this case was the most severe in this series and 3 years old at the time of operation. Compared with the patient's preoperative condition, however, hand mobility remained improved after 3.5 years of follow up. The angle of passive flexion of the hyperextensible MCP joint was 50° preoperatively, 5° at 6 months after surgery, and 10° from 12 months

Fig. 2 Preoperative and postoperative serial lateral radiographs of the thumb CMC joint of a 64-year-old woman in group 1. **a** Before surgery. **b** After surgery. This K-wire was removed 2 months after surgery. **c** At 3 months after surgery. **d** At 6 months after surgery. **e** At 9 months after surgery. **f** At 2 years after surgery

Fig. 3 A 75-year-old woman in group 2a. **a** The patient demonstrating thumb metacarpal adduction and MCP hyperextension deformities. Her ability to pinch and grasp an object tightly was severely compromised. **b** Lateral radiograph and computed tomography(CT). **c** Three-dimensional CT of the thumb demonstrating the collapsed thumb deformity. **d** Correction by means of an Ilizarov mini-fixator after CMC arthroplasty.

The correction of the MCP joint contracture in the direction of extension was initiated after achieving sufficient opening of the joint space with long-axis traction (*arrow 1*). In the following step, correction of the first web contracture was initiated using perpendicular frames (*arrow 2*). **e, f** Three years later, there had been no recurrence and the outcome was satisfactory both clinically and radiographically

to 3 years after surgery. The active movement of MCP joint was well maintained in all cases after this treatment showing 30–45° (mean 36°). There were no serious complications such as refractory infection, fracture, or intolerance to the external fixator that led to its early removal.

Case Presentation

Patient 1 (Group 1) Figure 2 shows the pre- and postoperative radiographs of the thumb CMC joint of a 64-year-old woman with a severe MCP joint hyperextension deformity (Fig. 2a). CMC arthroplasty was performed, and the joint was fixed with an extension block K-wire for 2 months (Fig. 2b). However, the deformity recurred within a few months of removing the pin (Fig. 2c, d). The patient underwent corrective percutaneous osteotomy with an IMF at the neck of the metacarpal

(Fig. 2e). Although the additional surgery reduced the patient's satisfaction emotionally, there was no recurrence for 2 years after the second surgery (Fig. 2f).

Patient 2 (Group 2a) A 75-year-old woman had a hyperextension deformity at the MCP joint of her right thumb for over 2 years. She had complained of difficulty using clothespins for a year before presenting to us. In addition, she was unable to extend the interphalangeal joint of her thumb, and it had worsened progressively in the previous 6 months. Her right thumb had a severely collapsed zigzag deformity due to advanced CMC arthritis (Fig. 3a–c). IMF setting and CMC arthroplasty were performed at the same time, and correction of the collapsed thumb by IMF was started immediately after the surgery, as previously described (Fig. 3d). Three years later, we found that the active range of motion of her thumb was maintained, she could move her thumb without pain, and there had

Fig. 3 (continued)

been no recurrence. The outcome was satisfactory both clinically and radiographically (Fig. 3e, f).

Discussion

Hyperextension of the first MCP joint and adduction of the first web space of the hand are features of the advanced stages of CMC joint arthritis. Failure to recognize and treat MCP deformities may result in continuous pain, recurrent deformities, and longitudinal collapse [1–5]. Based on the results of our previous study and this case series [3], we speculated that a recurrence of hyperextension of the first MCP joint might be deeply related to the increase in VT angle, the slope of the first metacarpal base, and the severity and duration of the MCP joint contracture. In this case series, all cases showed excessive VT angle showing a sharp slope of the base of the first metacarpal, and the cases with MCP degenerative changes showed poor recovery after surgery. If the hyperextended MCP joint needs to be flexed more than 40° or the history of a deformity exceeds 3 years, the possibility of successful correction by external fixators may be reduced. Our results also indicated the relatively high risk of recurrence associated with extension block by K-wire, even if a hyperextension deformity could be corrected by passive flexion of $<20^\circ$ on preoperative examination. To avoid recurrence, it seems important to correct the afflicted joint properly after joint traction by external fixators. Patient satisfaction as measured by VAS score was not high among patients in group 1, possibly because of the MCP degenerative changes or distrust of our medical staff due to recurrence emotionally.

Our study reports the results of a small clinical investigation of the use of external fixators for formative and cosmetic correction of collapsed thumb deformities in patients with advanced stages of CMC arthritis. Although the number of cases is small, this study provides possible indications and limitations of this method. However, the present method has advantages and disadvantages over the previous method, with the algorithm showed a correlation between clinical and radiographic findings [2, 5, 10–12]. As an advantage of our approach, we could preserve thumb MCP joint components including extension restraint that plays a functional role of passive ligamentous action and active muscular action [13]. Our cases showed excellent active MCP movement, this result seemed to due to surgical rehabilitation by IMF without using surgical technique. The present method is safer and less invasive because it leaves atrophic muscles and other soft tissues intact. This case series demonstrates the potential of the IMF system for achieving functional and cosmetic formative correction. The IMF system can increase the indication range of a collapsed thumb with advanced CMC arthritis. However, patients may complain about the bulky appearance of the systems and the amount of time and effort required during post-operative management to correct deformities and prevent recurrence. Success of the procedure depends largely on post-operative management and careful patient evaluation.

Taken together, the results of this small case series encouraged us to propose a surgical strategy for severely collapsed zigzag thumb deformities by gradual correction with external fixators. Good outcomes with no recurrence are highly anticipated if a hyperextended MCP joint has no obvious degenerative changes and can be corrected by $<40^\circ$ of passive flexion before CMC arthroplasty.

Statement of Human and Animal Rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation 140 (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Copyright and Conflict of Interests Disclosure YH declares that he has no conflict of interest. AK declares that he has no conflict of interest.

KS declares that he has no conflict of interest. RS declares that he has no conflict of interest.

NH declares that he has no conflict of interest.

Statement of Informed Consent Identifying information, including patients' names, initials, or hospital numbers, were not published in written descriptions, photographs, and pedigrees.

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