Introduction

Arthritis of the trapeziometacarpal (TM) joint (also known as the 1st carpometacarpal joint), is one common osteoarthritis in the hand. It is relatively common in middle-aged women, amounting up to 10% of individuals [1-3]. A failed conservative treatment needs operative management. However, no operative method is universally accepted. There are various operative methods for TM joint arthritis, including first metacarpal osteotomy, ligament reconstruction, trapeziectomy, trapeziectomy with ligament reconstruction and tendon interposition (LRTI), trapeziectomy and tendon interposition, arthrodesis, and arthroplasty [4-
The operative method should be selected based on the patient’s age, functional demand, occupation, medical conditions, and the operative surgeon’s experience, knowledge, and preference [8,9].

According to a recent evidence-based study, trapeziectomy with LRTI remains the most popular treatment of choice at present [8]. Historically, resection arthroplasty with or without tendon surgery is more indicated than other procedures for patients who do light or moderately light work for which good mobility is decisive, while strength is of less importance [1,2,4]. In terms of arthrodesis, it is recommended for active young patients without an arthritic change in the scaphotrapeziotrapezoidal (STT) joint [10,11]. Different instruments for arthrodesis were used in previous practices, including Kirschner wire (K-wire), interosseous wiring, screw fixation, and even plate. The union rate in the arthrodesis site is associated with clinical outcomes and highly depends on the fusion technique [12].

This study aimed to determine whether arthrodesis performed on patients with Eaton-Littler stage III TM joint arthritis would lead to favorable functional outcomes. In addition, as previous studies have used various types of hardware for TM joint arthrodesis, we compared adding the interosseous wiring over transaxial fixation of K-wires or headless compression screws with only multiple headless screws fixation.

### Methods

**Ethics statement:** The study design was approved by the local Institutional Review Board (IRB) of CHA Bundang Medical Center (No. CHAMC 2022-02-055-002). The requirement for patient consent was waived by the IRB due to the retrospective design of this study.

This retrospective single-center cohort study was performed in compliance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [13]. Even after undergoing adequate conservative treatment, including rest, physical therapy, medication, brace immobilization, and steroid injections, patients with TM joint arthritis were considered for surgical intervention if persistent pain significantly interfered with their daily activities. Patients with Eaton-Littler stage III degenerative TM arthritis who underwent surgery between 2009 and 2022 were analyzed. During the study period, we conducted 51 operations for Eaton-Littler stage III degenerative TM arthritis. Cases involving trapeziectomy with LRTI performed due to challenging arthrodesis or STT joint arthritis were excluded (one patient) from the study. Further, we excluded patients fixed with only K-wire (three patients).

One senior expert hand surgeon chose the arthrodesis method and conducted all operations. Two separate orthopedic residents collected data from the operating hospital medical database. Patients who did not have a minimum of three months of follow-up after being discharged from the hospital or were lost to follow-up before achieving bony union were not included in the study (three patients).

### 1. Surgical technique and postoperative management

Under regional or general anesthesia, a curvilinear operative incision was marked centering over the TM joint. The underlying subcutaneous tissue was dissected with precaution so as not to damage the superficial radial nerve. Between the abductor pollicis longus and extensor pollicis brevis, we longitudinally incised fascia and spread two tendons bilaterally, followed by joint capsule incision and arthritic joint exposure. To mobilize the joint, volar and dorsal joint capsules were released with a scalpel. With proper exposure after removing the synovium and osteophyte, the articular surface of the 1st metacarpal base and the trapeziun were resected with an electric saw or rongeur, creating cancellous surfaces perpendicular to the longitudinal axes of both bones. The thickness of resection was less than 2 mm on each surface. To target an arthrodesis angle with 30° to 40° palmar abduction and 20° to 30° radial abduction, we attempted to widen the contact area of the prepared surface of the two bones as much as possible. After one or two K-wire temporary fixation, proper resected joint apposition and adequate position and fixation of the K-wire were confirmed under the C-arm. For fixation, if there was sufficient space for at least two headless screws to be inserted with adequate stability, only headless screws were used. We employed screws between Depuy-Synthes headless compression screw (3.0 and 2.4 mm; Depuy-Synthes, New Castle, PA, USA) and Medartis cannulated compression screw (2.2 mm; Medartis, Basel, Switzerland). Additionally, a small amount of healthy cancellous bone from the resected bone was attempted to be inserted, particularly if there was a gap between the arthrodesis interface (Fig. 1).

However, because achieving adequate stability with multiple headless screws was not initially expected due to the small bone size, interosseous wiring over transaxial K-wire or headless screw fixation was used. The 16-gauge intravenous catheter needles were inserted by bicortical transverse drilling across the trapezium and the base of the 1st metacarpal bone for passing the interosseous wire. A 25-gauge steel wire was passed inside needles. Intravenous catheter needles were then removed. The

---

**Fig. 1**
Fig. 1. (A) Trapeziometacarpal joint incision. (B) The incision between the abductor pollicis longus and extensor pollicis brevis, and joint exposure. (C) Resection of the metacarpal base and trapezium articular surfaces. (D) Target arthrodesis angle with 30° to 40° palmar abduction and 20°-30° radial abduction. (E) Insertion of healthy cancellous bone from resected bone into gaps.

contact surface was compressed and secure fixation was achieved by the tension of the interosseous wire (Fig. 2).

The detached capsule was attempted to repair with vicryl, followed by a simple skin suture with nylon. A thumb spica splint was applied after sterile dressing. Interphalangeal joint movements were allowed if the pain was tolerable. The skin stitch was removed around 2 weeks after surgery and a removable thermoplastic brace was applied at around postoperative 4 weeks. If the patient had percutaneous insertion of K-wires, they were removed at around 4 weeks after surgery.

2. Variables, data sources, and measurement

Data on patient characteristics such as age, sex, direction, and precedent trauma experience were collected from a medical database. Postoperatively, the number and size of the screw used were recorded. On serial X-ray radiography follow-up, we determined the time to union defined as the presence of bony trabeculae crossing the arthrodesis site in at least three among four views on hand series X-ray images using a picture archiving and communication system software (Maroview; Infinitt Healthcare Co. Ltd., Seoul, Korea) without evidence of in-
For clinical outcomes, we evaluated the visual analogue scale (VAS) score for pain, quick Disability of Arm, Shoulder, and Hand (DASH) score, grip strength, and pinch strength preoperatively and at the final follow-up. Grip power was measured using a Jamar Hydraulic Hand Dynamometer (Sammons Preston, Bolingbrook, IL, USA). Pinch strength was measured using a Jamar Pinch Gauge (Sammons Preston). The unit of grip strength was kg. Finally, we investigated any complications that had occurred before treatment termination. Depending on the presence or absence of interosseous wiring fixation, we divided patients into two groups: group 1, those using 25-gauge wiring with K-wire or headless compression screw for fixation; group 2, those using two or more headless compression screws.

We compared groups in terms of basic characteristics, operation time, clinical outcomes, and complications. Basic characteristics included age, sex, and hand direction. We assessed the operation time written in the operation record except for patients who underwent any combined surgery. To compare union time, we used average value except for nonunion complication patients. When we compared clinical outcomes, we also excluded patients who underwent other procedures together with fixation. The evaluated complications were as follows: superficial incisional wound infection, deep wound infection requiring wound revision, superficial radial nerve injury, fracture during procedure, implant loosening, nonunion, and rate of implant removal even after union [14,15].

**3. Satisfaction assessment**

During the study period, we attempted to contact patients by telephone. In the telephone phone survey, we also assessed the satisfaction of each patient using the following question: “How would you describe the result of the treatment received at the time immediately before arthrodesis and now?”. Possible results were ‘very satisfied’ (score of 5), ‘satisfied’ (score of 4), ‘average’ (score of 3), ‘poor’ (score of 2), and ‘very poor’ (score of 1).

**4. Statistical analysis**

Before comparisons were performed, every variable underwent a normality test (Shapiro-Wilk test). Continuous variables with positive normality are presented as the mean and standard deviation, and continuous variables with negative normality are presented as the mean and interquartile range (IQR). Categorical variables are presented as numbers and percentages. A single comparison of continuous values was performed using the Student t-test or Wilcoxon rank sum test. The Fisher exact test was used to compare categorical variables. A p-value of less than 0.05 was considered statistically significant.

**Results**

Finally, 44 hands of 39 patients (5 patients had surgery for both hands) were collected. There were 13 male and 26 female patients. Their average age at surgery was 60.1 years (range, 41–80 years). Among the 44 hands, 15 were right and 29 were left.

Among overall patients, six patients reported previous trauma history and one patient had been treated with closed pinning for...
traumatic TM joint fracture dislocation that eventually led to arthritic change. The rest had primary arthritis with an idiopathic cause.

Besides TM joint arthrodesis, ulnar shortening osteotomy in two patients, A1 pulley release in five trigger thumbs and one 4th trigger finger, carpal tunnel release in three patients, lateral epicondylitis in one patient, one wrist arthroscopy, and opposite wrist Sauve-Kapanji procedure in one patient were conducted together. The median value of follow-up duration was 262.0 days (IQR, 139.0–461.0 days) in group 1, and 284.5 days (IQR, 115.0–395.0 days) in group 2.

1. Comparison of basic characteristics and clinical outcomes

In group 1, adding on interosseous wiring, K-wires were inserted in six hands (one wire in one hand, two wires in four hands, and three wires in one hand) and screws were inserted in 15 hands (one screw in 12 hands and two screws in three hands). In group 2, fixation with two headless compression screws was conducted for 13 hands and three headless screws for 10 hands (Fig. 3).

There were no statistically significant differences in age, hand direction, operation time, or follow-up duration (Table 1). In terms of sex, group 1 had 16 females and two males, and group 2 had 10 females and 11 males, showing a statistically significant difference between the two groups. The union time was slightly longer in group 2 than in group 1. However, such a difference was not statistically significant (Table 2). In comparisons of clinical outcomes such as pain VAS, DASH score, and strength, both groups presented better outcomes than preoperative status. Preoperative grip and pinch power showed a significant differ-

Fig. 3. (A, B) Arthrodesis with one interosseous wiring and two Kirschner wires. (C, D) Arthrodesis with one headless compression screw and one interosseous wire. (E, F) Arthrodesis with two or three headless compression screws. (G) A satisfactory postoperative range of motion was obtained in the thumb. All fixation methods mentioned above also obtained a satisfactory postoperative range of motion of the thumb.
Table 1. Basic characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>18</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>No. of hands</td>
<td>21</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td>0.017*</td>
</tr>
<tr>
<td>Female</td>
<td>16 (88.9)</td>
<td>10 (47.6)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2 (11.1)</td>
<td>11 (52.4)</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td>61.0 ± 7.9</td>
<td>59.3 ± 9.1</td>
<td>0.542</td>
</tr>
<tr>
<td>Direction</td>
<td></td>
<td></td>
<td>0.675</td>
</tr>
<tr>
<td>Right</td>
<td>6 (28.6)</td>
<td>9 (39.1)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>15 (71.4)</td>
<td>14 (60.9)</td>
<td></td>
</tr>
<tr>
<td>Operation time (min)</td>
<td>70.0 (55.0–80.0)</td>
<td>60.0 (55.0–78.0)</td>
<td>0.754</td>
</tr>
<tr>
<td>Follow-up (day)</td>
<td>262.0 (139.0–461.0)</td>
<td>284.5 (115.0–395.0)</td>
<td>0.875</td>
</tr>
</tbody>
</table>

Values are presented as number only, number (%), mean ± standard deviation, or median (interquartile range).

Group 1, the patients who underwent surgery with 25-gauge interosseous wiring and Kirschner wire or headless screw fixation; group 2, the patients who underwent surgery with only multiple headless screws for fixation.

*p < 0.05, statistically significant.

Table 2. Outcome comparison between groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union time (day)</td>
<td>62.0 (51.0–74.0)</td>
<td>75.0 (57.0–111.0)</td>
<td>0.043</td>
</tr>
<tr>
<td>Pain VAS score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>4.0 (2.5–5.0)</td>
<td>5.0 (3.0–6.0)</td>
<td>0.234</td>
</tr>
<tr>
<td>Final</td>
<td>1.0 (1.0–2.0)</td>
<td>2.0 (1.0–3.0)</td>
<td>0.115</td>
</tr>
<tr>
<td>DASH score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>52.2 ± 20.4</td>
<td>39.5 ± 23.5</td>
<td>0.084</td>
</tr>
<tr>
<td>Final</td>
<td>20.4 ± 12.0</td>
<td>18.6 ± 8.7</td>
<td>0.627</td>
</tr>
<tr>
<td>Strength assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative grip</td>
<td>14.5 ± 5.9</td>
<td>21.7 ± 10.6</td>
<td>0.011*</td>
</tr>
<tr>
<td>Final grip</td>
<td>22.0 (18.0–30.0)</td>
<td>25.5 (20.0–35.5)</td>
<td>0.351</td>
</tr>
<tr>
<td>Preoperative pinch</td>
<td>3.0 (1.0–4.0)</td>
<td>5.0 (3.0–7.0)</td>
<td>0.024*</td>
</tr>
<tr>
<td>Final pinch</td>
<td>5.0 (4.0–8.0)</td>
<td>7.0 (4.0–8.5)</td>
<td>0.492</td>
</tr>
</tbody>
</table>

Values are presented as median (interquartile range) or mean ± standard deviation.

VAS, visual analogue scale; DASH, Disabilities of Arm, Shoulder and Hand.

Group 1, the patients who underwent surgery with 25-gauge interosseous wiring and Kirschner wire or headless screw fixation; group 2, the patients who underwent surgery with only multiple headless screws for fixation.

*p < 0.05, statistically significant.

2. Complication comparison

In group 2, one patient who presented erythematous local heat after surgery was treated with oral antibiotics. No patient underwent wound management for deep infection (Table 3).

Two patients in group 1 and three patients in group 2 presented a tingling sensation or paresthesia along with superficial radial nerve dermatome postoperatively. However, these symptoms resolved with observation. No patient required additional treatments such as injection or exploration. There was no intraoperative fracture or tendon injury from operations.

We encountered a total of five patients with nonunion, two asymptomatic, and three symptomatic. Group 2 presented higher rates of nonunion with patients (17.4%) than one patient of group 1 (4.8%) without statistical significance. Despite a nonunion, one patient in group 1 reported less pain than the preoperative condition. There was no implant loosening and no further treatment was followed (Fig. 4). Among four nonunion hands in group 2, one patient was a heavy smoker, and although he was advised to quit smoking after surgery, he continued to smoke. The other patient was taking the methotrexate for rheumatoid arthritis and was unable to stop treatment due to rheumatic symptoms even after surgery, and progressed to nonunion. Among four patients, three reported persistent clinical symptoms from nonunion and underwent revisional osteosynthesis, plate conversion as well as auto iliac bone graft. In the end, all three patients achieved arthrodesis union.

Two patients visited the outpatient clinic for different hand problems (one distal radius fracture in the opposite wrist and one TM joint arthritis in the other hand) at postoperative 3 years and 8 years each. Checked X-ray of the postoperative hand revealed sclerosis of STT joint without joint collapse. Nevertheless, the patients did not report clinical symptoms of the operated hand. Only four patients in group 1 claimed that the implant-induced discomfort and irritation. They underwent fixation instrument removal including interosseous wiring.
3. Satisfaction results

Among 39 patients, 29 patients could be contacted to answer our question. Of 33 operated hands (four patients were operated for both hands), nine (27.3%) were rated as 'very satisfied,' sixteen (48.5%) were rated as 'satisfied,' and eight (24.2%) were rated as 'average.' No patient reported poor or very poor outcomes for the operated hand. However, seven patients could not be contacted and three patients refused to answer our questions.

Discussion

We compared arthrodesis outcomes in Eaton-Littler stage III TM joint arthritis depending on the presence or absence of intersosseous wiring fixation (only headless compression screws versus intersosseous wiring with axial headless compression screw or K-wire fixation). Larger bone in male patients could only allow screw fixation as a fixation method. Group 1, which added intersosseous wiring, showed a higher fusion success rate at 95.2% compared to 82.6% in group 2, although it was not statistically significant. Nevertheless, in group 1, four patients required removal surgery after union due to instrument discomfort caused by wiring and other fixation implants.

In terms of operative techniques in TM joint arthritis, there are various surgical options and their modifications. Nevertheless, therapeutic challenges remain because no technique guarantees successful outcomes, and the gold standard was not established until now [3]. Eventually, the surgical treatment remains largely based on the personal preference of individual surgeons [8,9,16]. Also, 93% of surgeons performed only one type of surgical procedure [8].

The authors consistently applied arthrodesis as a surgical treatment modality for patients with stage III TM joint arthritis, except in cases where fixation was difficult due to the destruction of the trapezium. Thanks to that, even with the surgeon’s limited experience in surgically treating the disease, we were able to experience and report relatively many cases of arthrodesis. In addition, it was possible to compare the clinical results and nonunion incidence rates of adding intersosseous wiring on transaxial fixation.

In the literature, trapeziectomy with LRTI remains the most popular treatment of choice at present [8]. A high complication rate has been a reason for not favoring arthrodesis [3,4,6,17-19]. In terms of complications, a recent systematic review of TM joint arthrodesis has reported that the most common major complication is symptomatic hardware necessitating additional surgery (8.6%) and that the second most common complication is nonunion requiring additional surgery (4.3%) [3]. It also noted minor complications of peritrapezial arthritis (8.5%), followed by nonunion (8.4%; asymptomatic and/or not requiring surgical management), radial nerve neuropathies (5.5%), superficial infections (1.9%), and complex regional pain syndrome (1.2%).

Although an expert hand surgeon conducted all surgeries according to levels of experience previously defined [20], we were also not free from complications that occurred after arthrodesis. Our experiences showed similar rates of hardware removal after union (four hands, 10.2%) and symptomatic nonunion (three hands, 6.8%) as major complications. Regarding minor complications, we also experienced asymptomatic nonunion (two hands, 4.5%), superficial infections (one hand, 2.3%), and superficial radial nerve neuropathies (five hands, 11.4%).

In terms of nonunion, not all cases of nonunion cause clinical symptoms, including pain. Asymptomatic nonunion is observed and can mimic a partial resection arthroplasty [21]. Nevertheless, nonunion is the most common complication and critical issue in arthrodesis reporting up to 25% of the cases [3,12]. Among the various factors contributing to nonunion, the fusion technique has a significant impact. In a systematic review, the most frequent fixation method for arthrodesis was K-wire at 51.3%, followed by plate fixation at 24.6%, screw fixation at 9.8%, tension band technique at 7.1%, staple fixation at 7.0%, and none at 0.1% [3]. However, only K-wire fixation was more frequently linked with nonunion [17]. The optimal fixation method should offer complete stability through compression,
facilitating the early movement of neighboring joints and enhancing the union rate [22].

If the bone stuff was enough for inserting more than two headless screws, we used only screws for stable fixation. Several studies have reported good results for TM joint arthrodesis using a headless compression screw without a plate [23,24]. A recent biomechanical study compared various fixation methods for arthrodesis, including crossed 1.1-mm K-wires, crossed 1.6-mm K-wires, crossed headless compression screws, compression plating, and locked compression plating. The results indicated that crossed headless compression screws provided the highest level of overall stability [25]. Therefore, it is suggested that using crossed headless compression screws for arthrodesis may be the optimal choice, as long as the size of the bone allows for it. Recently, small-sized headless screws (smaller than original screws with a diameter of 3.0 mm) are available, enabling fixation with multiple screws in small bones of hands such as the hands of women and Asian patients.

Nevertheless, for small bones, we applied interosseous wiring over K-wire or one-screw axial fixation. Stokel and colleagues conducted a biomechanical stability study of four TM joint fixation methods [26]. The tension band wire displayed the highest level of stability when subjected to torsional forces. They concluded that combined cerclage wires and K-wires fasten the fusion area. Finally, in our group comparison interosseous wiring in addition to transaxial fixation (group 1) resulted in a lower nonunion rate (one patient, 4.8%) than group 2 (four patients, 17.4%). Since it did not reach a statistically significant difference, we could not argue that adding the interosseous wiring over transaxial fixation of K-wires or headless compression screws is superior to multiple headless screws. Moreover, four patients in group 1 requested implant removal after TM joint arthrodesis union due to the implant-induced discomfort and irritation.

When applying arthrodesis, the following condition should be considered: no arthritic change in the STT joint. Nevertheless, arthrodesis in the TM joint could lead to STT arthritic change, although it was not initially noted before arthrodesis due to stress distribution on the STT joint [11,17,27]. If a patient had newly developed arthritis and pain, additional procedures such as trapeziectomy with ligament reconstruction might be needed. Therefore, STT arthritis occurrence was checked by the authors. Despite various outpatient follow-ups, we could only find STT sclerosis changes in two patients without clinical symptoms at 3 years and 8 years after TM arthrodesis, respectively.

This study has several limitations. Firstly, the relatively large but still limited sample size remains a constraint. In addition, it was a retrospective study. In order to obtain sufficient stability, the operating surgeon decided on the fixation method considering the size of the trapezium, and we believe that the surgical conditions between the two groups cannot be the same.

Moreover, there was no comparison with other procedures such as trapeziectomy or ligament reconstruction. A comparative study using headless compression screw with plate-based arthrodesis or other procedures will be of great help in determining the surgical treatment plan for TM joint arthritis.

Conclusion

Adequate stability can be achieved during arthrodesis by combining interosseous wiring and other implants or multiple headless compression screws, resulting in successful outcomes for patients with Eaton-Littler stage III degenerative TM arthritis.

ORCID

Jun-Ku Lee, https://orcid.org/0000-0003-4640-9357
Chi-Hoon Oh, https://orcid.org/0000-0002-7495-7062
Woo Yeol Ahn, https://orcid.org/0000-0001-5664-222X
Sung Woo Lee, https://orcid.org/0009-0001-9890-5603
Seungyeon Kang, https://orcid.org/0009-0000-4561-7563
Soo-Hong Han, https://orcid.org/0000-0002-8951-650X

Conflicts of interest

The authors have nothing to disclose.

Funding

This work was supported by National Health Insurance Service Ilsan Hospital grant (NHIMC2023CR075).

References


