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Outcomes of First Metacarpal Extension Osteotomy for Base of Thumb Arthritis

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Abstract

Background: First metacarpal extension osteotomy (FMEO) aims to correct the adduction deformity associated with thumb arthritis, as well as improve the congruity at the first carpometacarpal (FCMC) joint. However, the benefits of this procedure are currently unclear. The purpose of this study is to investigate the outcomes of FMEO in the treatment of FCMC joint arthritis.

Methods: Electronic databases were searched systematically for original data studies in the English language reporting outcomes following FMEO for base of thumb arthritis. Data were extracted from the text, tables, and figures of publications and meta-analyzed where possible.

Results: Ten publications comprising 211 thumbs were included. FMEO was associated with an improvement in pain relief and patient-reported functional outcomes, however meta-analysis showed no significant long-term improvement in grip strength or lateral pinch grip. Although there was disease progression in one third of patients after FMEO, most did not require further procedures. Outcomes following secondary procedures was not analyzed in the literature. FMEO produced a range of minor complications, however, major complications were rare.

Conclusions: The available evidence suggests FMEO does not improve grip or pinch strength. However, it may have a role in analgesia and improvement in functional outcomes. Further studies should compare outcomes of FMEO to continued nonoperative treatment, or other surgical options including arthroscopy or ligamentous reconstruction.

Keywords: thumb, anatomy, bone, basic science, arthritis, diagnosis, osteoarthritis, surgery, specialty

Introduction

First carpometacarpal (FCMC) joint osteoarthritis is the second most common form of arthritis in the hand, and can lead to pain, hypermobility, and deformity at the base of the thumb.[1] The FCMC joint lacks bony stability, and relies largely on ligamentous support, particularly from the dorsoradial (DRL), the anterior oblique ("beak") (AOL), and the intermetacarpal ligaments.[2] Of these, the DRL is the most important stabilizer of the FCMC joint; transection of the DRL results in more than twice the translational distance of joint subluxation compared to the AOL.[3-5] The intermetacarpal ligament serves to curb radial subluxation. Although it has no role in providing stability to the FCMC in the power grip and pinch positions, degeneration of the AOL is thought to be a precursor to CMCJ joint arthritis.[2,6] The subsequent development of radial subluxation leads to an adduction contracture of the first web space and compensatory metacarpophalangeal joint hyperextension.[7]

Several surgical options have been described for the management of FCMC joint arthritis refractive to nonoperative measures, their selection dependent upon the stage of arthritis. A 2015 Cochrane review[8] found that no single procedure was superior in terms of pain relief and function—however, there was insufficient evidence to be conclusive. First metacarpal extension osteotomy (FMEO) is an option for patients, usually with early-stage disease.[9] It involves creating a radial closing-wedge osteotomy at the base of the thumb to abduct the distal first metacarpal by thirty degrees. The primary aims of the procedure are to correct the adduction contracture and provide analgesia, by improving the congruity of the FCMC joint and redistributing axial loading forces from the eroded volar articular cartilage to the

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healthier dorsal surface.[10] The extra-articular nature of the procedure also easily permits secondary procedures if the disease progresses.

The aim of this study was to assess the outcomes of FMEO for base of thumb arthritis by systematically reviewing the literature, comparing functional outcomes, disease progression, and complication rates. We hypothesized that FMEO provides functional improvement in a carefully selected patient population.

Materials and Methods

Search Strategy

A literature search was performed in January 2021 in accordance with PRISMA guidelines,[11] using the databases Embase, PubMed, Ovid Medline, and the Cochrane Controlled Register of Trials. To improve the penetration of the search strategy, various combinations of the terms "thumb," "osteotomy," "carpometacarpal joints," and "osteoarthritis" were employed as keywords, MeSH terms, or via wildcard enquiries.

Eligibility Criteria

Studies that were published in the English language and reported outcomes following FMEO for base of thumb arthritis were eligible for inclusion. Primary outcomes of interest were strength, disease progression and functional status. Studies which included the use of adjuncts such as ligament reconstruction and arthroscopic debridement were excluded. Reference lists of all studies were manually screened to identify further potentially relevant articles. Articles were reviewed by 2 authors to determine relevance, and any disagreements on inclusion or exclusion were resolved via consensus. Case reports, abstracts, conference presentations, editorials, and expert opinions were excluded.

Data Extraction and Analysis

Data were extracted from the text, tables, and figures of the included studies. Study authors were contacted if reported outcomes were unclear. Due to heterogeneity in research design and patient population, a descriptive narrative synthesis was utilized for most outcomes. In some instances, similarities in study design permitted collation and comparison of data, with a meta-analysis performed to evaluate grip and lateral pinch strength. Review Manager 5 software (Cochrane Community, London, United Kingdom) was used to perform statistical analysis. Heterogeneity in the data was assessed visually using forest plots, and quantitively using the I^2 and χ^2 statistics. Significant heterogeneity was defined as $I^2 > 50\%$ and $P < .1$. A random effects model was used to present the results to account for expected clinical heterogeneity due to variation in population and surgical characteristics. Continuous outcomes (grip strength, lateral pinch strength) were analyzed using the standardized mean difference (SMD).

Results

A total of 143 articles were identified from the initial search of electronic databases. After removal of duplicates, 104 remained for screening of title and abstract. Of these, 23 were selected for full-text review. Two further articles were found while screening the reference list of studies assessed. Ten papers met the inclusion criteria (Figure 1). All included studies were level 4 in the hierarchy of evidence.

Study Design

All 10 publications included were level 4 studies. A total of 211 thumbs were assessed (Table 1).

Grip Strength

Four studies measured pre- and post-operative grip strengths in patients undergoing FMEO. Grip strengths were measured with a mean follow-up time of 4 weeks,[18] 4 years,[15] 9 years,[19] and 12.3 years.[12] There was no significant increase in follow-up grip strength in all groups (SMD 0.32 kg; 95% confidence interval [CI]: -0.64, 1.29; $P = .51$), but there was significant heterogeneity in the studies reporting this outcome ($I^2 = 70\%$, $P = .02$) (Figure 2).

In addition to the 4 studies, Tomaino[20] reported a statistically significant increased grip strength of 8.5 to 24 kg ($n = 12$) at 2.1 years post-operatively. However, the author no longer had access to the data, and without the standard deviation, this study was not able to be included in the meta-analyses.

Lateral Pinch Grip

Bachoura et al[12] and Parker et al[19] reported pre- and post-operative lateral pinch grip strength following first metacarpal extension osteotomy, with a mean follow-up period of 9 years and 12.3 years, respectively. There was no significant change in lateral pinch strength following surgery (SMD: -0.14 kg, 95% CI: -1.00, 0.71; $P = .74$) (Figure 3). Pre-operative grip strength was comparable between the 2 studies, with no significant heterogeneity detected ($I^2 = 25\%$, $P = .25$).

In addition to these 2 studies, Tomaino[20] also reported a statistically significant increased grip strength from 3 to 6 kg ($n = 12$) after 2.1 years. Again, the data were no longer available, and thus was not able to be included in meta-analysis.

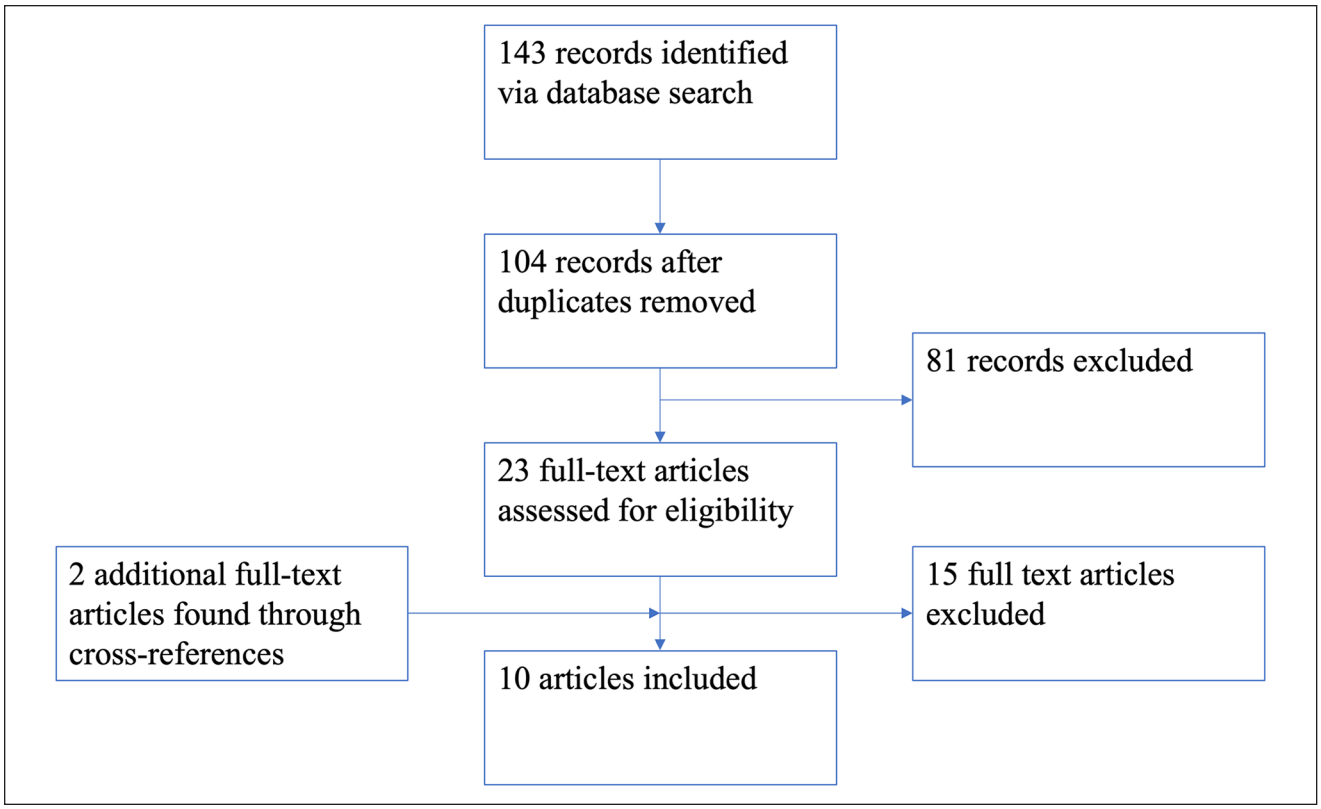

Figure 1. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow-chart detailing search process.

Patient Reported Outcomes

Prior to surgery, all patients included in this review experienced persistent moderate to severe levels of pain which interfered with hand function and activities of daily living (ADLs).[13,14,16,18-21] When assessed using the visual analogue pain scale, most patients in Holmberg's[17] study reported some degree of pain relief at 8.5 months after surgery, with a mean reduction of 4 units (scale 0-9). After 2.1 years, Tomaino[20] found the average pain score decreased from 5 to 1. At 9.9 years, Chou et al[13] measured the mean value of pain to be 2.0 (scale 0-7). Similarly, Gwynne-Jones et al[14] found a significant increase in mean Michigan Hand Outcomes Questionnaire score from 27 to 71, equating to regular and severe pain affecting ADLs improving to rare mild pain. Hobby et al[16] and Parker et al[19] also reported a significant proportion of patients to be pain-free at 6.8 and 9 years, respectively.

A small subset of patients in the studies by Hobby et al,[16] Holmberg and Lundborg[17] and Parker et al[19] did not experience any improvement in pain with the procedure. Only 1 patient from Holmberg and Lundborg's[17] study and 1 patient from Tomaino's[20] study could not return to work due to thumb-related issues.

A registry-based analysis reported that patients with CMC arthritis have a mean quickDASH score of 56,[22] corresponding to significant impairment of ADLs, coordination, dexterity, functional mobility, and quality of life. Long-term outcomes of FMEO reveal marked improvements in physical function and symptoms, with Chou et al[13] reporting a decrease in quickDASH to 24.17 at 9.9 years, and Bachoura et al[12] describing a similar score of 27.7 after 12.1 years. Almost all other patients reported they were satisfied with the outcome.[15,19-21]

Radiographic Outcomes

Futami et al[15] reported no radiographic stage progression at 4 years post-operatively. Chou et al[13] found that 63% of patients remained at the same Eaton stage at 9 years follow-up, with the remainder advancing radiographically by 1 stage. Similarly, Parker et al[19] reported that 63% of patients did not progress, a quarter progressed 1 stage, and a single patient demonstrated radiographic deterioration by 2 Eaton stages. Of those with progression, all patients maintained good strength and function after surgery.

Further Operative Intervention

Bachoura et al[12] performed a Kaplan-Meier analysis, and predicted a 70% probability that patients would not require an additional procedure for up to 14 years following a

Table 1. Summary of Study Design.

Author/year study published/reference	Design	Level of evidence	N (thumbs) undergoing osteotomy	Fixation method
Bachoura et al[12] Survival and long-term outcomes of thumb metacarpal extension osteotomy for symptomatic carpometacarpal laxity and early basal joint arthritis	Retrospective case series	IV	32	K-wires
Chou et al[13] Long-term follow-up for first metacarpal extension osteotomy for early CMC arthritis	Retrospective case series	IV	20	Osteosuture + K-wire
Gwynne-Jones et al[14] Basal thumb metacarpal osteotomy for trapeziometacarpal osteoarthritis	Retrospective case series	IV	28	Plaster only
Futami et al[15] Osteotomy for trapeziometacarpal arthrosis	Prospective case series	IV	12	K-wires
Hobby et al[16] First metacarpal osteotomy for trapeziometacarpal osteoarthritis	Prospective case series	IV	41	K-wires
Holmberg and Lundborg[17] Osteotomy of the first metacarpal for osteoarthrosis of the basal joints of the thumb	Prospective case series	IV	18	Osteosuture + K-wire
Molitor et al[18] First metacarpal osteotomy for carpo-metacarpal osteoarthritis	Retrospective case series	IV	12	K-wires
	Prospective case series	IV	5	K-wires
Parker et al[19] Long-term outcomes of first metacarpal extension osteotomy in the treatment of carpal-metacarpal osteoarthritis	Retrospective case series	IV	8	Osteosuture
Tomaino[20] Treatment of Eaton stage I trapeziometacarpal disease with thumb metacarpal extension osteotomy	Prospective case series	IV	12	Staples
Wilson and Bossley[21] Osteotomy in the treatment of osteoarthritis of the first carpometacarpal joint	Prospective case series	IV	23	Osteosuture

Note. K-wire = Kirschner wire; CMC = carpometacarpal.

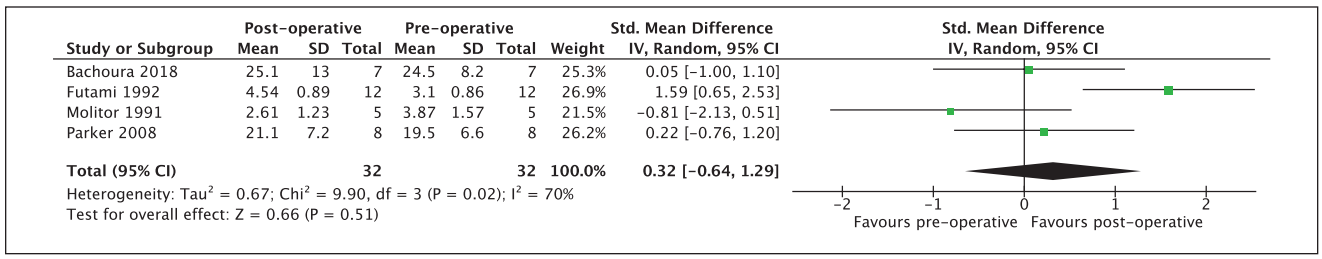

Figure 2. Forest plot of grip strength before and after extension osteotomy.
Note. CI = confidence interval.

FMEO. Chou et al[13] and Wilson and Bossley[21] reported that none of their patients have required further interventions. However, a minority of patients in studies by Bachoura et al,[12] Gwynne-Jones et al,[14] Hobby et al,[16] Holmberg and Lundborg[17] and Parker et al[19] progressed to require secondary procedures for persistent symptoms. These included basal joint arthroplasty,[12,19] CMC joint arthrodesis[14,16] and trapeziectomy with interposition arthroplasty.[14,17] Follow-up data on outcomes following conversion to secondary procedures were not analyzed in the literature.

Complications

Only 2 major complications were reported across the literature—1 patient developed osteomyelitis despite oral antibiotics,[12] while another had a deep infection with subsequent malunion.[16] No other major complications were reported.[17-19,21]

The most common minor complication reported was superficial pin site infections which resolved with oral antibiotics.[12,16] Minor loss of sensation at the tip of the thumb,[21]

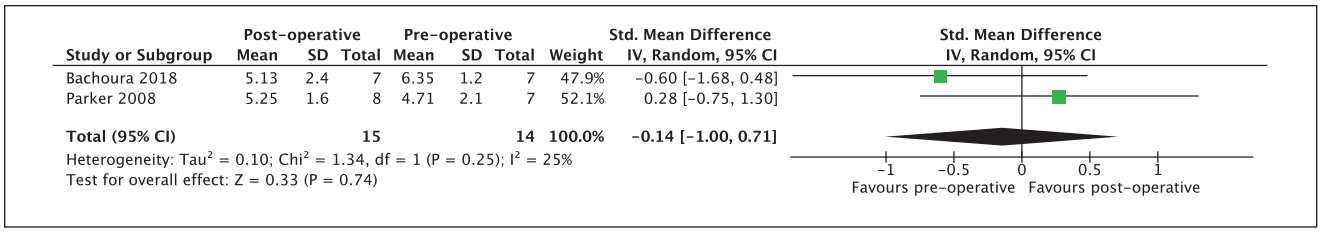

Figure 3. Forest plot of lateral pinch strength before and after extension osteotomy.
Note. CI = confidence interval.

temporary dysaesthesia in the superficial radial nerve distribution[14,16] and transient mild algodystrophy[14,16] were also documented.

Delayed union at the site of osteotomy was rare.[14,16] In an early study, Wilson[23] reported that FMEO failed to adequately correct the preoperative adduction deformity in a minority of patients. However, alleviation of clinical symptoms was noted, with the patients continuing to grasp large objects utilizing compensatory metacarpophalangeal joint hyperextension. Similarly, Parker et al[19] noted that a single patient had a slight loss of abduction at the osteotomy site, without any clinical significance.

Discussion

This study analyzed 10 papers and found that first metacarpal extension osteotomy for base of thumb arthritis provided pain relief and improvement in patient-reported functional outcomes. However, meta-analysis showed no significant improvement in post-operative grip strength or lateral pinch grip strength with long-term follow-up. A third of patients experienced radiographic disease progression, though most patients did not require secondary operative intervention. Major complications were rare, although there were a number of associated minor complications.

Advocates for FMEO have suggested that correcting the adduction deformity and stabilizing the CMC joint can lead to pain relief and functional improvement, as well as acting to slow disease progression. Shrivastava et al[24] demonstrated that simulating a 30-degree abduction osteotomy reduces joint laxity in all directions in the position of lateral pinch, compared to pre-operative values. Pelligrini et al[10] also found that force was effectively offloaded dorsally from the arthritic palmar surfaces. Cadaveric studies have suggested that FMEO may provide similar CMC joint stability in the lateral pinch position compared to ligamentous reconstruction.[25] In addition, Tomaino[26] found in a preliminary study that extension osteotomy provides satisfactory pain relief and improved pinch and grip strength, with short-term results comparable to ligamentous reconstruction. Despite this, the current study demonstrates no significant improvement in grip or pinch strength post-operatively. Primary stabilizers of the CMC joint are ligamentous, particularly in movements like opposition, abduction, adduction, and retropulsion.[27] Hence, osteotomy alone without ligamentous reconstruction may be inadequate to provide the stabilization required for manual ability and grip strength, particularly in the long-term. Bryant et al[28] demonstrated that double ligament reconstruction of the AOL and DRL was able to significantly increase mean grip and pinch strength in patients with Eaton stage I or II FCMC arthritis. However, the optimal surgical management of base of thumb arthritis remains contentious.

One of the strengths of this study was the inclusion of papers with variable mean follow-up periods ranging from 4 weeks to 12.3 years.[12-21] This allowed for the evaluation of longitudinal surgical outcomes including radiographical disease progression, long-term complications and the need for further operative intervention. However, there were a number of limitations. The studies included had significant heterogeneity, with variation in fixation method, surgeon experience and patient selection. For example, there were cohort disparities in disease severity, measured by the pre-operative Eaton classification of radiographic disease. Although most of the studies focused on early-stage arthritis defined as Eaton stage I or II, there were several studies which included Eaton stage III and IV disease in their patient cohort.[12,14-17,19] Further sub-stratification based on disease severity would be of benefit; however, the data was not presented in a manner permitting this more detailed analysis. There was also variation in the reporting of outcome measures and control groups, precluding meta-analysis. A number of studies provided comparison to the contralateral hand, with potential confounding due to the possibility of underlying arthritic changes.[13,17,19] Gwynne-Jones et al[14] and Hobby et al[16] used different data sets used for comparison as age and sex matched normative values, creating another source of heterogeneity. All articles included were case series, and therefore prone to selection and publication bias. A minority of patients lost to follow-up in 3 studies also introduced a potential source of bias.[13,14,20]

In conclusion, the results of this systematic review suggest metacarpal osteotomy is effective in improving patient

reported outcomes, in particular pain relief in FCMC arthritis, however the procedure does not improve grip and pinch strength post-operatively. A prospective randomized controlled trial comparing FMEO to continued nonoperative measures, or other therapeutic options for base of thumb arthritis (such as arthroscopy or ligament reconstruction), would be useful.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

The article does not contain any direct studies with human or animal subjects.

Statement of Informed Consent

There was no requirement for consent as this was a systematic review and meta-analysis.

Declaration of Conflicting Interests

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