Review Article

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Hemi-hamate Arthroplasty for Base of Middle Phalanx Fracture: A Systematic Review

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Abstract

Intra-articular fracture dislocations of the base of the middle phalanx are complex and debilitating injuries that present a management conundrum when nonreconstructable. Hemi-hamate arthroplasty (HHA) is a treatment modality of particular use in the setting of highly comminuted fractures. This systematic review aims to summarize the reported outcomes of HHA in this context. A literature search was conducted using MEDLINE, Embase, and PubMed, yielding 22 studies with 235 patients for inclusion. The weighted mean postoperative range of movement at the proximal interphalangeal joint was 74.3° (range, 62.0°-96.0°) and at the distal interphalangeal joint was 57.0° (range, 14.0°-80.4°). The weighted mean postoperative pain Visual Analog Scale was 1.0 (range, 0.0-2.0). The weighted mean postoperative grip strength was 87.1% (range, 74.5%-95.0%) of the strength on the contralateral side. Posttraumatic arthritis was reported in 18% of cases, graft collapse in 4.2%, and donor site morbidity in 3.0%, with a mean follow-up period of 28.4 months (range, 1-87 months). Hemi-hamate arthroplasty is a reliable and effective technique for the reconstruction of intra-articular base of middle phalangeal fracture dislocations, affording symptomatic relief and functional restoration. Further research is required to assess the true incidence of long-term complications.

Keywords: hemi-hamate arthroplasty, base of middle phalanx, fracture

Introduction

Intra-articular fracture dislocations involving the base of the middle phalanx and extending into the proximal interphalangeal joint (PIPJ) are challenging injuries to manage and often require complex surgical reconstruction. These fractures are typically a result of an axial loading force to the digit, resulting in hyperextension at the PIPJ and associated dorsal subluxation/dislocation. The management is dependent on the fracture configuration and articular stability, with involvement of greater than half the articular surface rendering the joint highly unstable.[1] Treatment modalities include open reduction and internal fixation (ORIF), percutaneous pinning, external fixation, extension block splinting, volar plate arthroplasty, hemi-hamate arthroplasty (HHA), and salvage procedures such as hemi-joint or total joint arthroplasty or arthrodesis. There is currently no consensus on optimal technique in the setting of comminution and sizable articular involvement, with current literature suggesting similar outcomes. However, fixation may prove difficult and reconstruction may be favored to avoid chronic pain, osteoarthritis, instability, and limited range of movement (ROM).[2-4]

Hemi-hamate arthroplasty was first suggested by Hastings et al in 1999[5] and involves reconstruction of the volar aspect of the middle phalangeal base with an osteochondral autograft harvested from the distal hamate. A 2015 review of outcomes following HHA suggested that this technique may provide reliable reconstruction of PIPJ fractures.[6] Since then, a number of further studies have been published,

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providing a significantly larger cohort for analysis. Thus, this review aims to provide an updated summary on the outcomes of HHA in the treatment of intra-articular base of middle phalangeal fractures.

Methods

Search Strategy and Study Selection

This systematic review was performed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines.[7] The literature search was conducted using the MEDLINE, Embase, and PubMed databases from their inception through to November 2020, with search terms including (hemi hamate arthroplasty.mp) AND ((exp proximal interphalangeal joint/) OR (PIPJ.mp) OR (exp middle phalanx/)) modified as appropriate for each database. A bibliographic review was also performed to identify additional articles.

Included studies were English-language papers reporting outcomes of HHA in the treatment of intra-articular middle phalangeal base fractures. Studies were excluded if they did not report relevant outcomes such as postoperative ROM, pain, or functional scores; contained nonhuman subjects; reported on a pediatric (less than 18 years old) population; or reported outcomes for multiple operative techniques or fracture types without isolating HHA and base of middle phalanx fracture results. Conference abstracts were also excluded.

Data Extraction

Title and abstract screening, full-text screening, and data extraction were performed by 2 independent authors, with conflicts resolved via discussion and senior review. Extracted variables included demographic data (such as number of patients, age, sex distribution, and length of follow-up), fracture characteristics (including digit and articular surface involvement), and outcomes. Outcomes comprised metacarpophalangeal joint (MCPJ), PIPJ, and distal interphalangeal joint (DIPJ) ROM; pain visual analog scale (VAS); grip strength; Disabilities of the Arm, Shoulder, and Hand (DASH) score; posttraumatic osteoarthritis; and graft collapse and donor site complications.

Study quality was assessed using the methodological index for nonrandomized studies critical appraisal system,[8] which scores noncomparative studies on a scale from 1 to16 based on 8 criteria.

Data Analysis

Descriptive statistics were calculated and displayed in tables, with continuous variables expressed as weighted means (with weighting based on the relative number of patients) and categorical variables as proportions.

Results

The literature search yielded 68 articles; after removal of duplicates, 49 studies underwent abstract and full-text screening. A total of 22 studies were eligible for inclusion in the systematic review (Figure 1), comprising 16 retrospective case series, 3 prospective case series, and 3 case studies (Table 1). Common reasons for exclusion included anatomical or cadaveric studies (n = 11), studies reporting nonoriginal data (n = 9), and studies focused on surgical technique (n = 4).

The 16 included studies reported on a cohort of 235 patients, with a weighted mean age of 33.8 years. There were 190 men (81%) and 45 women (19%).

The injured digit was the index in 25 cases (12.3%), the middle in 72 cases (35.5%), the ring in 82 cases (40.4%), and the little in 24 cases (11.8%). Two studies with 32 patients did not report on the involved digit. The weighted mean articular surface involvement was 58.7% (range, 31%-90%). Time to surgery was reported for 199 patients, with a weighted mean delay of 53.6 days (range, 4-440 days) between injury and undergoing HHA. Length of follow-up was reported for all studies, with a weighted mean of 28.4 months (range, 1-87 months). The mean study quality was 10 (range, 7-14, out of a possible 16).

Range of Movement

All studies reported postoperative active PIPJ ROM (Table 2), with a weighted mean of 74.3° (range, 62.0°-96.0°). Six studies also reported the difference between preoperative and postoperative PIPJ ROM; following surgery, there was a mean increase in the ROM of 48.3° (range, 31.0°-76.5°). Fourteen studies reported postoperative active DIPJ ROM, and among these, the weighted mean ROM was 57.0° (range, 14.0°-80.4°). Six studies reported postoperative active MCPJ ROM, with a weighted mean of 91.0° (range, 90.0°-94.0°).

Other postoperative ROM parameters included a weighted mean PIPJ flexion end point of 83.0° (range, 75.0° to 96.0°, reported by 11 studies) and a weighted mean extension lag of 13.0° (range, 8.9°-19.0°, reported by 7 studies).

Pain and Functional Outcomes

Twelve studies reported postoperative pain, with a weighed mean pain VAS of 1.0 (range, 0.0-2.0). The difference between preoperative and postoperative pain was reported by 4 studies; the utilization of HHA led to a mean decrease in the pain VAS of 5.4 (range, 3.4-8.0).

Sixteen studies reported postoperative grip strength; the weighted mean was 87.1% (range, 74.5%-95.0%) of the strength on the contralateral side. Two studies reported the difference between preoperative and postoperative grip strength, with surgery producing a mean improvement of

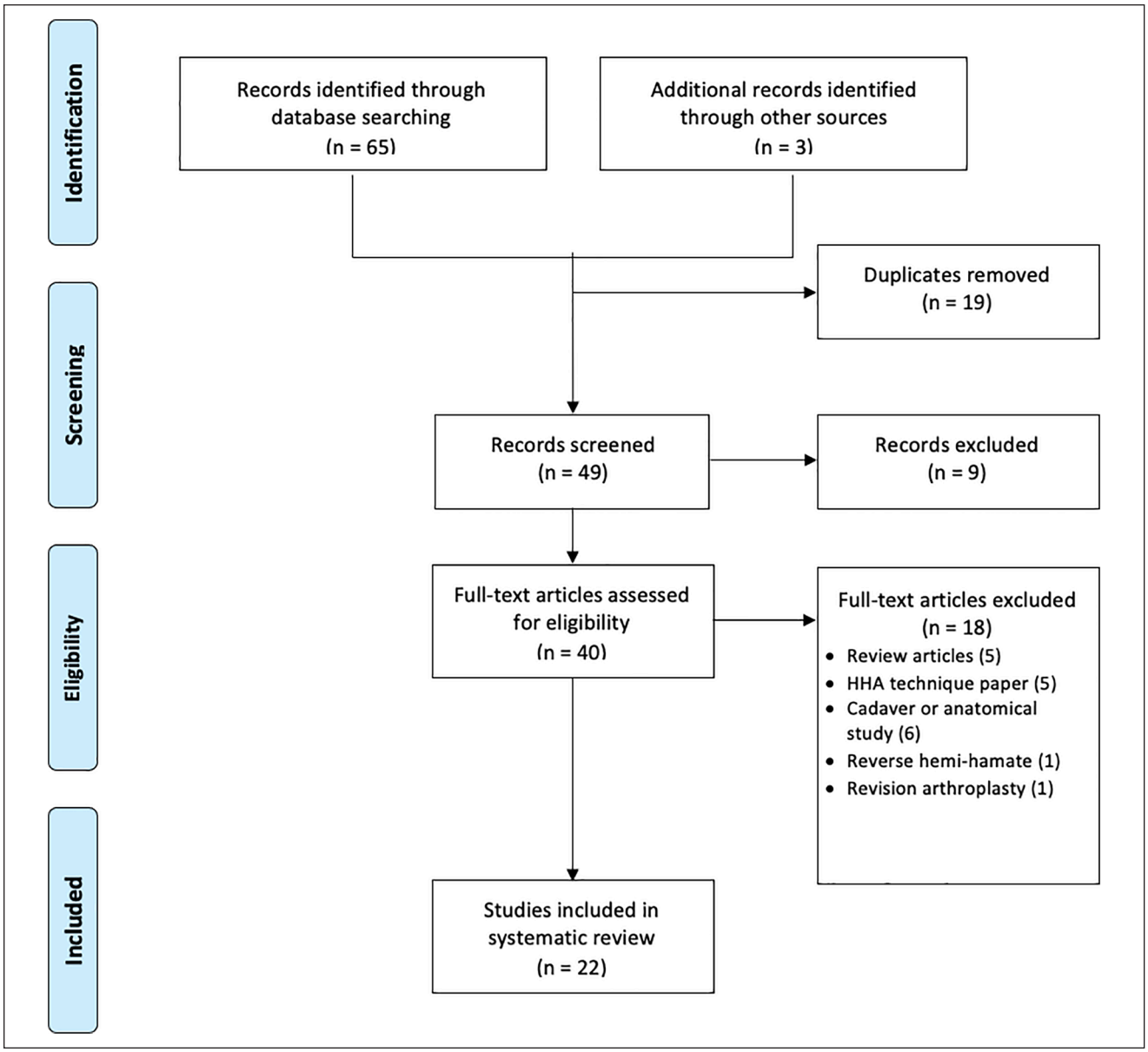

Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses flow diagram for the systematic review.
Note. HHA = hemi-hamate arthroplasty.

15.0% (range, 12.0%-17.5%) when compared with the contralateral side.

The postoperative DASH score was reported by 9 studies, with a weighted mean score of 9.2 (range, 2.3-19.0). The mean subjective hand function VAS was 2.6 (range, 1.9-4.0, reported by 3 studies).

Complications

Thirteen studies reported rates of posttraumatic arthritis at last follow-up, with a pooled incidence of 18% (27 of 152 patients). Of these cases, 85% were classified as mild (n = 23) and 15% as severe (n = 4). Graft collapse or failure was reported in 20 studies and occurred in 4.2% of cases (9 of 215 patients). Donor site morbidity as reported by 14 studies, with donor site pain or instability present in 3% of cases (4 of 133 patients). Fifteen studies reported radiographic union at follow-up, with nonunion observed in 1.2% of cases (2 of 162 patients).

Discussion

This systematic review collates the reported outcomes for HHA in the treatment of intra-articular base of middle

Table 1. Characteristics of the Included Studies.

Study	Design	No. of patients	Mean age (range)	Male %	Finger involvement	Mean involvement of articular surface (range)	Mean time to surgery, d	Mean follow-up, mo	Study quality
Afendras et al[9]	Retrospective case series	8	49 (25-66)	63	I = 0, M = 3, R = 4, L = 1	61% (52%-60%)	22	60	11
Barksfield et al[10]	Retrospective case series	7	39 (35-43)	100	NR	46% (31%-61%)	NR	3	12
Bigorre et al[11]	Case study	1	18	100	I = 0, M = 1, R = 1, L = 0	75%	120	12	9
Burnier et al[12]	Retrospective case series	19	39 (19-58)	89	I = 1, M = 7, R = 10, L = 1	>40%	84	24	11
Calfee et al[13]	Retrospective case series	22	35 (14-62)	59	I = 1, M = 6, R = 13, L = 2	63% (50%-90%)	NR	54	9
Goon et al[14]	Retrospective case series	4	21 (18-27)	75	I = 1, M = 0, R = 3, L = 0	73% (60%-90%)	440	24	7
Hussain et al[15]	Retrospective case series	20	29 (16-45)	75	I = 0, M = 11, R = 6, L = 3	70% (55%-90%)	11	24	10
Kato et al[16]	Retrospective case series	13	45 (14-66)	46	I = 2, M = 5, R = 3, L = 3	48% (43%-58%)	41	70	10
Korambayil and Francis[17]	Retrospective case series	5	27 (22-32)	100	I = 2, M = 1, R = 2, L = 0	60% (50%-70%)	32	22	8
Lindenblatt et al[18]	Retrospective case series	10	35 (26-46)	100	I = 1, M = 0, R = 5, L = 4	64%	93	9	9
Rozen et al[19]	Case study	1	25	100	I = 0, M = 1, R = 0, L = 0	60%	NR	3	7
Thomas et al[20]	Retrospective case series	6	29 (19-41)	100	I = 2, M = 2, R = 1, L = 1	53% (40%-60%)	NR	12	10
Thomas et al[21]	Retrospective case series	12	25 (17-37)	100	I = 2, M = 3, R = 5, L = 2	(40%-60%)	92	35	11
Verdins and Nefjodovs[22]	Retrospective case series	11	40 (22-65)	71	I = 1, M = 4, R = 6, L = 0	NR	39	6	9
Williams et al[23]	Retrospective case series	13	29 (15-50)	31	I = 3, M = 3, *R* = 6, L = 1	60% (40%-80%)	45	16	11
Yang et al[24]	Retrospective case series	11	30 (21-45)	73	I = 2, M = 3, R = 6, L = 0	58% (50%-59%)	4	38	9
Meena et al[25]	Prospective case series	25	25 (18-35)	96	NR	>40%	38	20	13
Arsad et al[26]	Case report	2	38 (28-48)	100	I = 0, M = 2, R = 0, L = 0	NR	30	18	8
Tang et al[27]	Retrospective case series	6	44 (28-69)	83	I = 2, M = 4, R = 0, L = 0	42% (32%-50%)	91	31	9
Najd Mazhar et al[28]	Prospective case series	15	35 (22-50)	100	I = 0, M = 9, R = 3, L = 3	57% (40%-70%)	65	30	11
Ayas et al[29]	Retrospective case series	11	34 (23-46)	73	I = 2, M = 5, R = 4, L = 0	50% (40%-60%)	34	30	11
Kibar[30]	Prospective case series	13	40 (19-66)	85	I = 3, M = 2, R = 5, L = 3	NR	6	12	14

Note. Finger involvement: I = index; M = middle; R = ring; L = little; NR = not reported. Study quality was assessed using the methodological index for nonrandomized studies criteria.[8]

Table 2. Outcomes of HHA for the Treatment of Base of Middle Phalanx Fracture/Dislocation.

Study	PIPJ ROM	DIPJ ROM	MCPJ ROM	Pain VAS	Grip strength	DASH	Arthritis (n)	Graft collapse
Afendras et al[9]	67 (45-95)	47 (15-90)	NR	1.0	91%	19.0	2 mild, 2 severe	1
Barksfield et al[10]	65 (31-108)	14 (10-46)	90 (83-95)	NR	NR	NR	NR	NR
Bigorre et al[11]	65	NR	NR	0.0	92%	2.3	0	0
Burnier et al[12]	66	41	NR	NR	82%	11.0	4 mild	0
Calfee et al[13]	70 (0-100)	54 (0-85)	NR	NR	95%	5.0	6 mild	1
Goon et al[14]	62 (26-102)	NR	NR	0.0	NR	NR	0	0
Hussain et al[15]	62 (40-90)	54 (40-65)	NR	NR	75%	NR	2 mild	0
Kato et al[16]	71 (35-105)	51 (15-85)	NR	NR	NR	NR	3 mild	NR
Korambayil and Francis[17]	96 (90-100)	NR	NR	NR	NR	NR	0	0
Lindenblatt et al[18]	71 (0-90)	54 (10-90)	94 (90-110)	NR	95%	NR	0	0
Rozen et al[19]	90	NR	NR	NR	NR	NR	NR	0
Thomas et al[20]	85 (70-100)	NR	NR	1.2	85%	NR	NR	0
Thomas et al[21]	77 (0-90)	NR	NR	2.0	81%	NR	NR	2
Verdins and Nefjodovs[22]	82 (60-90)	69 (30-90)	NR	0.6	93%	6.9	2 severe	0
Williams et al[23]	85 (65-100)	60 (35-80)	90 (75-100)	1.3	80%	NR	0	2
Yang et al[24]	85 (60-100)	80 (60-90)	92 (80-100)	0.3	95%	4.8	1 mild	0
Meena et al[25]	88 (75-100)	75 (75-90)	NR	NR	91%	NR	NR	0
Arsad et al[26]	78 (75-80)	55 (30-80)	NR	NR	76%	6.8	NR	0
Tang et al[27]	72 (60-80)	NR	NR	0.0	90%	NR	NR	0
Najd Mazhar et al[28]	64 (30-110)	60 (10-70)	90 (90-90)	1.7	88%	13.6	5 mild	0
Ayas et al[29]	75 (60-100)	NR	NR	0.3	NR	NR	NR	3
Kibar[30]	82 (60-90)	61 (30-80)	87 (75-100)	1.5	93%	7.6	NR	0

Note. PIPJ = proximal interphalangeal joint; DIPJ = distal interphalangeal joint; MCPJ = metacarpophalangeal joint; ROM = range of movement; VAS = Visual Analog Scale; DASH = Disabilities of the Arm, Shoulder, and Hand; NR = not reported.

phalangeal fracture dislocations, finding among other results a mean postoperative PIPJ ROM of 74.3°, a mean postoperative pain VAS of 1.0, and a mean postoperative grip strength of 87.1% on the contralateral side. Complications include posttraumatic arthritis, which was present in 18% of patients in this review, and graft collapse or failure, which was observed in 4.2% of cases.

A previous review of HHA outcomes performed in 2015 reported similar results from a smaller cohort of 71 patients, with a mean postoperative PIPJ and DIPJ ROM of 77° and 59°, respectively, as well as postoperative grip strength of 91% on the contralateral side.[6] Interestingly, these outcomes are comparable to results reported for other modalities used in the management of middle phalangeal base fractures, despite differing indications. In his systematic review, Demino et al[2] reported a mean postoperative PIPJ ROM of 84.7% with ORIF, 86.5% with percutaneous fixation, 81.7% with dynamic external fixation, 83.6% with extension block pinning, and 79.3% with HHA. Good grip strength was noted in all modalities, with a mean grip strength compared with the contralateral side of 85% for ORIF, 89% for dynamic external fixation, 95% for extension block pinning, and 85% for HHA. The lower ROM noted after HHA is likely a result of the more difficult fracture patterns for which it is used, as well as the invasive nature and technical difficulty of the procedure, rendering these other modalities an imperfect comparison group for HHA. In addition, HHA is used as a revision procedure when other modalities have failed.

The development of posttraumatic arthritis as a long-term complication of HHA remains an area of concern. The mechanism of arthritis in this setting is incompletely understood, but may involve joint surface imperfections and devascularization and denervation of the graft.[6] The reported incidence ranges dramatically and is as high as 50% in some studies.[6,9] However, the significance of radiographic changes and their correlation to clinical symptoms remain unclear. Afendras et al[9] reported radiographic signs of osteoarthritis in 50% of patients (4 of 8) in his series at 4-year follow-up; however, only 1 patient experienced troublesome pain. Similarly, Calfee et al[13] noted radiographic loss of joint space in 43% of patients, but found no correlation with clinical state. Indeed, patients with joint space narrowing had a mean pain VAS of 1.0 (which was below the mean for the cohort as a whole), and of the 4 patients with a perfect DASH score, 3 demonstrated radiographic signs of osteoarthritis. These discrepancies may be related to patient expectations and function, as well as insufficient follow-up. Many of the included patients are young and may develop symptoms to accompany the radiographic changes over the

ensuing years; long-term reporting may detect deteriorations in clinical outcome.

The comparative outcomes of HHA in the treatment of acute and chronic injuries are another area that may benefit from further inquiry. Our review (and many of the individual studies) included both acute and chronic cases, with a wide variation in delay from injury to surgery. There were no sufficiently isolated data for subgroup analysis or meaningful comparison, but superficially the outcomes appear similar. It is possible, however, that the long-term outcomes for acute injuries are somewhat better than those of a delayed and chronic nature, due to factors such as scarring and contractures at the time of surgery. Calfee et al[13] noted slightly higher rates of dissatisfaction and postoperative symptoms among patients with long-standing injuries. Similarly, Burnier et al[12] compared acute and chronic groups and found slightly higher postoperative PIPJ ROM for acute than for chronic injuries (69% and 63%, respectively), with a similar decrease in QuickDASH (7 for acute compared with 11 for chronic injuries). Other outcomes, however, were more favorable in the chronic group, such as postoperative grip strength (76% of contralateral side for acute and 87% for chronic).

A significant limitation of this review is the absence of controlled studies with a population for comparison. This is a common challenge in the surgical literature and complicates any determination of an optimal technique. Heterogeneous reporting also limited direct comparison between some studies (eg, reporting grip strength as a percentage of contralateral strength or by weight measurements) and reduced the pooled sample size for several of the outcome metrics. The inclusion of both acute and chronic injuries within many studies is evident in the wide range of time to surgery and prevented further analysis of these distinct pathologies which would ideally be examined separately. The relatively short follow-up of many of the included studies may result in underestimation of complications, particularly long-term processes such as posttraumatic arthritis. Reliance on outcome measures such as the DASH score may also misrepresent the true burden of postoperative functional impairment, given that pain-free but stiff joints can substantially impact fine motor tasks. Finally, disparity in aspects of surgical technique and postoperative protocols (such as length of immobilization) may account for some of the observed variation in outcomes.

Conclusion

This systematic review of HHA for the treatment of intra-articular base of middle phalangeal fracture dislocations found a weighted mean postoperative PIPJ ROM of 74.3°, a weighted mean postoperative pain VAS of 1.0, and a weighted mean postoperative grip strength of 87.1% of the contralateral side. Arthritis was observed in 18% of cases, with graft collapse in 4.2% and donor site morbidity in 3%. These outcomes suggest that HHA is a reliable and effective technique for the reconstruction of these complex injuries, particularly in cases of significant comminution. Further research is required to assess long-term outcomes and complications.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

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

Statement of Informed Consent

This is a review article using only pooled, previously published data, and informed consent was not required.

Declaration of Conflicting Interests

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