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Nonoperative treatment of distal humerus fractures in the elderly yields satisfactory functional outcomes and low conversion to delayed surgery: a systematic review

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Background: Distal humerus fractures (DHFs) pose a treatment challenge in elderly patients. We sought to systematically review and report the clinical outcomes of the nonoperative approach (eg, "bag of bones") for the treatment of these injuries and the rate of conversion to delayed surgery.
Methods: A comprehensive review of the literature using the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines was conducted. Studies involving outcomes after nonoperative treatment of DHF in patients >65 years of age were included from 1985 to present. Data regarding patient age, DHF type, nonoperative treatment method, complications, conversion to delayed surgery, range of motion, union rate, and surgeon- and patient-reported outcome measures were extracted.
Results: A total of five studies met inclusion criteria (all level IV evidence), yielding a total of 143 patients (mean age: 73.5 years to 87.4 years) with 7.1 months to 55 months of follow-up. The mean Mayo Elbow Performance Index scores were good to excellent across several studies (range 83-93.1). Multiple studies reported good range of motion (mean arc of motion: 81 to 106 degrees) and low levels of upper extremity disability (mean Quick Disability of the Arm-Shoulder-Hand scores: 31.3 to 38.5) at the final follow-up. The rate of conversion to total elbow arthroplasty and operative fixation ranged from 0% to 7.5% and 0% to 5%, respectively.
Conclusion: Nonoperative management of distal humerus fractures in the elderly seems to be associated with acceptable functional outcomes and low rates of delayed surgery. This information is important for patient counseling and treatment decision-making.

Distal humerus fractures (DHFs) account for 1%-2% of all fractures and represent 30% of fractures about the elbow.[12,13] These injuries often occur in elderly patients with osteoporotic bone after low-energy falls.[12] Before the 1960s, DHFs were treated nonoperatively with brief immobilization followed by early range of motion.[20] Historical small-volume studies reported favorable outcomes with this so-called "bag of bones" approach.[5,11] However, after development of the Arbeitsgemeinschaft für Osteosynthesefragen (AO) fracture fixation principles,[20] surgical implants and techniques improved, and patients experienced better outcomes with open reduction internal fixation (ORIF).[40] Plate osteosynthesis has since remained the gold standard of treatment for most DHFs, particularly in patients with good bone quality.[20] However, in patients with osteoporosis and multifragmentary comminution, the feasibility of ORIF is challenged.[20] Prosthetic replacement with total elbow arthroplasty (TEA) has shown promise in these patients,[21,26,29,31] as well as those with rheumatoid arthritis, failed fixation, and nonunion.[8,23,32] Consequently, nonoperative treatment has been reserved for low demand, medically unwell patients with advanced comorbidities that preclude surgery.[20,31]

However, operative management is not without risk. Infection, neurovascular injury, hardware failure, and elbow stiffness are well-documented postoperative complications.[1,37] The incidence of

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postoperative complications after ORIF and TEA is 53% and 11%-38%, respectively.[36,39] Thus, in addition to the general anesthetic risks of surgery, the risk of perioperative complications must be weighed against the added clinical benefits of operative intervention.

The purpose of this study was to systematically review and report the clinical outcomes and the rate of conversion to delayed surgery after nonoperative management of geriatric DHF.

Materials and methods

Identification of studies

This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines.[25] We performed a literature search using the PubMed, Scopus, and Cochrane Central Registrar of Controlled Trials databases from 1985 to present. 1985 was the year that ORIF gained acceptance over nonoperative management for DHF and was therefore used as a set point for our inclusion criteria.[18,19] Our search was conducted using several combinations of the terms 'nonoperative', 'management', 'conservative', 'treatment', 'distal humerus fracture', 'fractures of the distal humerus', 'elderly', and 'geriatric'. Two reviewers (S.S. and R.P.) independently screened titles and abstracts for inclusion and exclusion criteria. Full-text articles were obtained and reviewed when necessary. The references of all selected articles were reviewed to find articles that may have been overlooked or were not indexed in the databases.

Inclusion criteria were as follows: all available studies that reported on outcomes after nonoperative management of DHF of AO or Orthopaedic Trauma Association (OTA) classification A, B, and C. A minimum average follow-up of 6 months was required. The mean inclusion age was ≥65 years to remain consistent with other reports that examined fragility fracture management of the upper extremity in elderly patients.[2,4,7]

Exclusion criteria were as follows: case reports or case series with <2 patients, studies with abstract-only available, studies that failed to separate outcomes among surgically and nonsurgically treated patients with DHF, and studies published before 1985.

Analysis of bias

Two reviewers (S.S. and R.P.) independently appraised the quality of each study with use of the methodological index for nonrandomized studies (MINORS) criteria.[34] The criteria assess 8 critical aspects of study design for noncomparative clinical studies. Each item is given a score of 0 if information is not reported, 1 if information is reported but inadequate, and 2 if information is reported and adequate. Therefore, the maximum possible score is 16 for noncomparative studies. If there was any discrepancy between the results of the 2 reviewers, the item in question was discussed with the senior author (M.E.M.), who made the final determination of the MINORS score.

Data extraction

Study characteristics, AO or OTA fracture classification, and intervention details were extracted. If the level of evidence was not explicitly stated in the study, we used the classification as specified by Wright et al[38] to determine the level of evidence. Clinical outcome measures (Oxford Elbow Score [OES], American Shoulder and Elbow Surgeons score, Mayo Elbow Performance Index [MEPI], Quick Disability of the Arm-Shoulder-Hand [Q-DASH], or elbow range of motion) and conversion to delayed surgery (TEA or ORIF) served as our primary outcomes. The indication for reoperation was provided if available. Secondary outcomes included radiographic assessment of healing (Bröberg-Morrey classification or fracture union rate).

Statistical analysis

Given the inherent heterogeneity and limitations of level IV studies, pooled statistics were not reported to avoid potentially inaccurate conclusions. The means and standard deviations (or range of data in cases where the standard deviation was not reported) were extracted from each study. Confidence intervals and effect sizes were calculated. These data were used to produce a forest plot depicting the conversion rates to delayed surgery after nonoperative management of geriatric DHF (Fig. 1).

Results

Study characteristics

Study identification and screening is summarized in Figure 2. Of the 397 total articles identified, 5 were included in the final review. There were 5 retrospective reviews (level IV) and 1 prospective review (level IV evidence) reported within the 5 articles.[1,3,10,30,35] Reported studies were conducted in Canada (n = 1),[10] France (n = 1),[30] Japan (n = 1),[35] and the UK (n = 2).[1,3] Risk of bias was assessed using MINORS criteria, with scores ranging from 8 to 12 (Table I).

Patient characteristics, fracture classification, and treatment details

A total of 143 patients were included. Patient samples ranged from 14 to 40 patients and were predominantly women (range, 57% to 91%). The mean age and follow-up period ranged from 73.5 to 87.4 years and from 7.1 to 55 months, respectively. The American Society of Anesthesiology scores were reported in three studies.[10,30,35] The Charlson comorbidity index was reported in one study.[1] Five studies used the AO or OTA classification to categorize fractures of the distal humerus.[1,3,10,30] In total, 47 fractures were type A, 26 were type B, and 56 were type C (Table I).

Nonoperative management varied with the immobilization method (sling, splint, fiberglass, or plaster cast), duration (mean range 2-7 weeks), and structure of physiotherapy (supervised or unsupervised) (Table II).

Patient-reported outcome measures

Patient-reported outcome measures (PROMs) were used in all studies. Three studies reported 3 or more PROMs.[1,10,30] The most commonly reported outcome measure was the MEPI (60%). The Q-DASH, OES, Visual Analog Scale, and Katz Index of Independence of Activities of Daily Living were reported in two studies. Pretrauma and the end of follow-up Katz scores were provided in one study and were found to be nearly identical.[30] Each of the remaining PROMs was obtained at the end of follow-up.

The mean MEPI scores were good to excellent across three studies (range, 83-93.1).[10,30,35] The mean Q-DASH and OES scores ranged from 31.3 to 38.5 and 30 to 46, respectively.[1,3,30] Pain at rest ranged from 0.4 to 4, whereas pain with activity ranged from 1.3 to 5.5.[1,3] The other outcome measures and their frequency of use are shown in Table III.

Range of motion

Three studies reported range of motion data.[10,30,35] The mean flexion ranged from 110° to 128°, and the mean arc of motion was

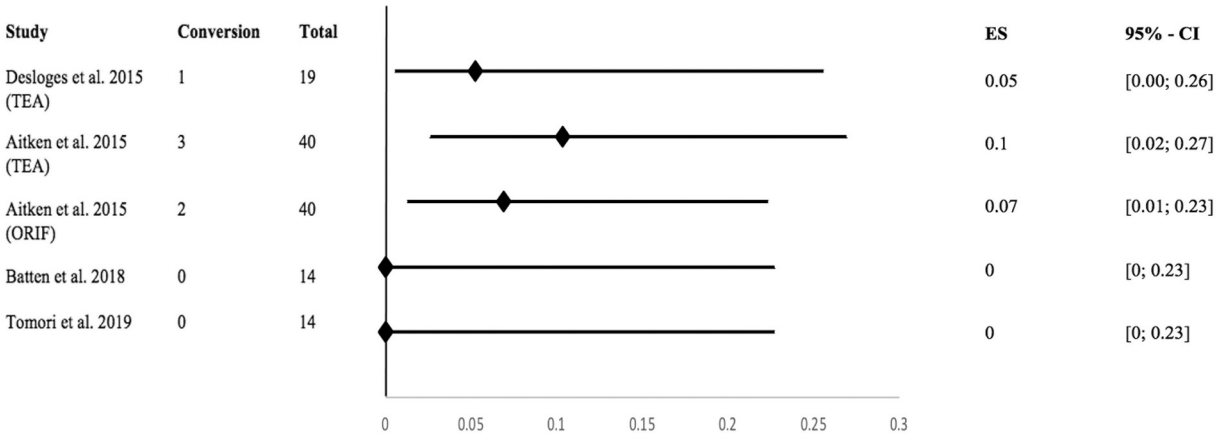

Figure 1 Rate of conversion to delayed surgery (TEA or ORIF) after nonoperative management of DHF, with forest plot displaying effect size (ES) (conversion rate represented by diamonds) and 95% confidence intervals (CIs) (horizontal lines). *TEA*, total elbow arthroplasty; *ORIF*, open reduction internal fixation; *DHF*, distal humerus fracture.

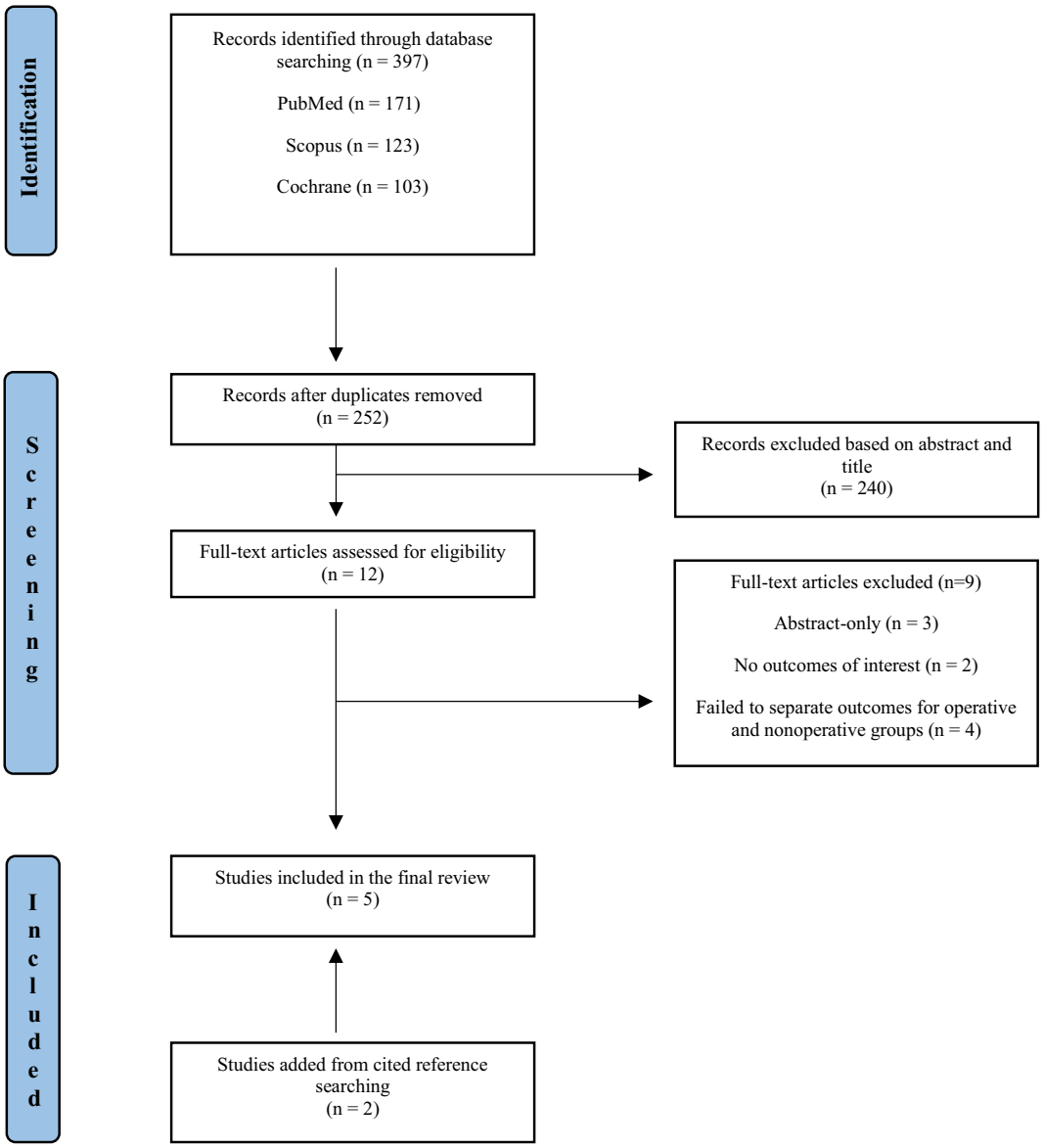

Figure 2 Preferred Reporting Items for Systematic reviews and Meta-analysis (PRISMA) article search flow diagram.

Table I
Patient demographics and characteristics of included studies.

Study (year)	Setting	Design	Level of evidence	Total patients (M/F), n	Age, mean (range), year	Follow-up, mean (range), months	Fracture classification	Subjective outcome	Functional and radiographic outcomes	MINORS score
Pidhorz et al[30] (2013)	France	RS	IV	34 (5/29)	84.7	20.2 (6-92)	A: 8 (23%) B: 4 (12%) C total: 22 (64%) C1: 12 C2: 7 C3: 3	Katz	Bröberg-Morrey, Q-DASH, MEPS	10
Pidhorz et al[30] (2013)	France	PS	IV	22 (2/20)	87.4	8.6 (6-20)	A: 10 (45%) B: 4 (18%) C total: 8 (36%) C1: 4 C2: 3 C3: 1	Katz	Bröberg-Morrey, Q-DASH, MEPS	12
Desloges et al[10] (2015)	Canada	PS	IV	19 (8/11)	77 (56-91)	27 ± 14 (6-57)	A: 3 of 19 B: 8 of 19 C: 8 of 19	SF-12 PREE (pain) Satisfactions scale	ASES, ROM, strength (MRCS), MEPS, PREE (function)	10
Aitken et al[1] (2015)	UK	RS	IV	40 (11/29)	73.5 (50 to 93)	46 (5-73)	A: 19/40 (47.5%) B: 7/40 (17.5%) C: 14/40 (35%)	Satisfaction score	ROM, OES, Q-DASH	8
Batten et al[3] (2018)	UK	RS	IV	14 (3/11)	76 (65-90)	55 (17-131)	A: 7/14 (50%) B: 3/14 (21%) C: 4/14 (29%)	VAS	OES	8
Tomori et al[35] (2019)	Japan	RS	IV	14 (6/8)	78 (46-98)	7.1 (3-16)	NR	NR	MEPS, ROM	9

MEPS, Mayo Elbow Performance Index; *Q-DASH*, quick-disability of the arm-shoulder-hand; *OES*, Oxford Elbow Score; *VAS*, visual analog scale; *PREE*, Patient-Rated Elbow Evaluation; *SF-12*; Short Form-12; *MCS*, Mental Health Composite Score; *PCS*, Physical Health Composite Score; *MINORS*, Methodological Index for Nonrandomized Studies.

Table II
Nonoperative treatment details.

Study (year)	Treatment details
Pidhorz et al[30] (2013)	Initial BABP plaster cast immobilization and Dujarrier bandage with switch to resin BABP cast at 3-4 weeks. Total immobilization time averaged 7 weeks (range, 15-120 days).
Desloges et al[10] (2015)	Immobilized at 90 degrees of elbow flexion with neutral forearm rotation for a mean of 5 weeks (range, 3-8 weeks), followed by active range of motion and supervised physiotherapy once radiographic union was achieved.
Aitken et al[1] (2015)	Initial above-elbow plaster splint with change to a sling at the first outpatient visit (within 14 days of injury) and instruction to perform unsupervised physiotherapy.
Batten et al[3] (2018)	Initial sling placement for comfort alone with instruction to immediately start supervised physical therapy.
Tomori et al[35] (2019)	Initial immobilization in a fiberglass cast or splint with removal at 6 weeks and commencement of active range of motion.

Table III
Patient-reported outcome measures.

Study (year)	Katz	MEPI	Q-DASH	OES	VAS-pain	Satisfaction	PREE	SF-12 MCS	SF-12 PCS
Pidhorz et al[30] (2013) RS	4.2	83	31.3 (0-72.7)	-	-	-	-		
Pidhorz et al[30] (2013) PS	4.3	86	34.4 (0-77.3)	-	-	-	-		
Desloges et al[10] (2015)	-	89.7 ± 10.8	-	-	-	-	15.6 ± 22.7	43.8 ± 5.6	59.3 ± 11.5
Aitken et al[1] (2015)	-	-	38.5 ± 28.2	30 ± 14.3	4 (0 to 5), 5.5 (2 to 8)*	7.1± 2.7	-		
Batten et al[3] (2018)	-	-	-	46 (29-48)	0.4 (0-6), 1.3 (0-9)*	-	-		
Tomori et al[35] (2019)	-	93.1 (85-100)	-	-	-	-	-		

RS, retrospective study; *PS*, prospective study; *MEPI*, Mayo Elbow Performance Index; *Q-DASH*, quick-DASH; *OES*, Oxford Elbow Score; *VAS*, visual analog scale; *PREE*, Patient-Rated Elbow Evaluation; *SF-12*, Short Form-12; *MCS*, Mental Health Composite Score; *PCS*, Physical Health Composite Score.
*The first value is pain reported at rest; the second value is pain with activity.

81° to 102.3°. The mean pronation and supination were 72° and 77°, respectively, as reported in one study (Table IV).[10]

Conversion to delayed surgery

Four studies reported on conversion to ORIF or TEA after nonoperative management of DHF.[1,3,10,35] The rate of conversion to TEA and time to conversion to TEA ranged from 0% to 7.5% and from 3 months to 17 months, respectively. The rate of conversion to ORIF and time to conversion for ORIF ranged from 0% to 5% and 3 months to 13 months, respectively (Table V).

Radiographic outcomes

Four studies reported on union rate, and one study reported on the presence of post-treatment osteoarthritis with use of the

Table IV
Range of motion data.

Study (year)	Flexion (degrees)	Extension (degrees)	Arc of motion (degrees)	Pronation (degrees)	Supination (degrees)
Pidhorz et al[30] (2013) RS	110	-	81	-	-
Pidhorz et al[30] (2013) PS	120	-	94	-	-
Desloges et al[10] (2015)	128 ± 16	-	106 ± 17	72 ± 13	77 ± 14
Tomori et al[35] (2019)	121.2 (90-140)	19.2 (5-30)	102.3 (70-130)	-	-

RS, retrospective study; *PS*, prospective study.

Broberg Morrey classification.[1,10,30,35] Standard anteroposterior and lateral radiographs of the elbow taken at 6-month follow-up were used to assess for fracture union. Overall, the mean union rate was 53% to 100%.[1,10,30,35] Thirty percent to 48% of patients had radiographic evidence of osteoarthritis (grade >1) at the final follow-up (range: 7 weeks to 60 months) (Table VI).[30]

Other outcomes

Quality of life scores from the 12-item Short Form Survey were 44 ± 11 on the physical component and 59 ± 6 on the mental component as reported in one study.[10] The mean patient-reported elbow evaluation score was 15.6 ± 22.7 (range, 0-83) as reported in one study.[10] Strength was evaluated using the Medical Research Council Scale in one study. No differences in elbow flexion and extension and grip strength were found when the injured side was compared with the uninjured side.[10] The mean satisfaction score was 7.1 ± 2.7 as reported in one study.[1]

Effect size

Effect sizes ranged from 0% to 10% (Fig. 1) among studies that reported on rates of conversion to delayed surgery (TEA or ORIF) after nonoperative treatment of DHF.[1,3,10,35]

Risk of bias

Risk-of-bias assessment, performed using the MINORS criteria scores, ranged from 8 to 12. The most common sources of possible bias were inadequate blinding or an unbiased assessment of endpoints, greater than 5% loss of patients at the final follow-up, absence of a prospective calculation of study sample size, and lack of a prospective collection of data.

Table V
Conversion to operative management.

Study (year)	Time to conversion (months)	TEA, %	ORIF, %
Desloges et al[10] (2015)	16	5.3	0
Aitken et al[1] (2015)	9	7.5	5
Batten et al[3] (2018)	N/a	0	0
Tomori et al[35] (2019)	N/a	0	0

RS, retrospective study; *PS*, prospective study; *TEA*, total elbow arthroplasty; *ORIF*, open reduction internal fixation; *N/a*, not applicable.

Table VI
Incidence of fracture union and osteoarthritis at the final follow-up.

Study (year)	Assessment time (months)	Union rate	OA*
Pidhorz et al[30] (2013)	20.2	95%	30%, 48%
Desloges et al[10] (2015)	12	81%	NR
Aitken et al[1] (2015)	12	53%	NR
Tomori et al[35] (2019)	1.75	100%	NR

OA, osteoarthritis; *NR*, not recorded.
*classified as a Broberg Morrey classification grade >1 for the PS and RS, respectively.

Discussion

Complex DHFs in elderly patients continue to present treatment challenges, and their prevalence is expected to rise 3-fold by 2030.[28] This systematic review aimed to evaluate outcomes after nonoperative treatment of geriatric DHF. Importantly, we show that acceptable functional outcomes are achieved with low conversion rates to delayed surgery.

Patient-centric care initiatives have changed the way providers view clinical outcome measures.[17] Focus has shifted toward PROMs, especially in cases where the added clinical benefit of invasive treatment options is questioned.[33] The MEPI score and the Q-DASH score were frequently reported PROMs within this study. The MEPI score is a reliable outcome instrument for elbow function that is used to assess nonsurgical treatment.[9] The performance index includes a score for pain (45 pts), mobility (20 pts), stability (10 pts), and daily activity (25 pts). On the basis of this system, the results are classified as excellent [100-90 pts], good [89-75 pts], average [74-60 pts], and poor [<60 pts].[6] The mean MEPI scores were good to excellent across all studies within this review (range 83-93.1). Similarly, the Q-DASH is a well-recognized self-report questionnaire designed to measure the overall functional capacity of the upper limb.[6] A 5-point Likert scale is used to grade the severity and function level for each of the 11 items on the questionnaire.[24] Scaled scores range from 0 (no disability) to 100 (most severe disability).[16] Patients in this study experienced low levels of upper extremity disability (Q-DASH 31.3 to 38.5) after nonoperative management of DHF.

Historic criticisms of nonoperative management include poor cast tolerance in the elderly with substantial risk for stiffness.[10] However, we found that a functional range of motion may be achieved after a mean period of 2 to 7 weeks of elbow immobilization. While immobilization methods differed (sling, splint, fiberglass, or plaster cast), complications were few and relatively benign. In total, 2 hematomas,[10] 2 localized pressure ulcers,[10,30] 3 fracture displacements not requiring surgery,[10] 2 symptomatic pseudoarthroses, 1 asymptomatic pseudoarthrosis,[30] 3 malunions, 6 cases of mild varus and valgus elbow laxity,[30] 2 cases of heterotopic ossification not requiring surgery,[30] and 4 cases of elbow stiffness secondary to bony impingement occurred.[30] All patients reported good function with ability to compensate adequately with the contralateral arm. No deep infections or elbow contractures requiring surgical release were reported.

A variable rate of fracture union (52.6% to 100%) resulted from nonoperative management of DHF. This was not unexpected as most fractures evaluated were comminuted and intra-articular. However, most nonunions were asymptomatic and compatible with the requirements of low-demand elderly patients, as evidenced by a low conversion rate to delayed surgery. Interestingly, a recent systematic review of 83 studies and 2363 elbows reported an overall reoperation rate of 21% after ORIF of intra-articular DHFs.[39] The reoperation rate for TEA varies across published studies, ranging from 5.7% to 11.3%.[14,15,22]

The indications for delayed surgery in our review included stiffness, poor function, and continued pain in 6 of 87 patients.

PROMs after delayed TEA were available for 1 patient.[10] She had a patient-reported elbow evaluation score of 2, MEPI score of 100, and adequate range of motion (flexion-extension: 5 to 115 degrees; pronation 90 degrees; supination 65 degrees) 37 months postoperatively. These results underscore the effectiveness of TEA in the delayed setting. Prasad and Dent[32] compared outcomes of primary TEA and delayed TEA after failure of conservative treatment for geriatric DHF. At a mean follow-up of 56.1 months (18 to 88 months), both groups experienced good outcomes in accordance with their MEPI scores (84 in the early group and 79 in the delayed group; $P > .05$). Subjective satisfaction was 92% in both groups, and no differences in survivorship were found. It has been proposed that elderly low-demand patients with DHF should first be treated nonoperatively, as successful salvage can be achieved with delayed TEA.[10]

Conversion to delayed surgery is ultimately dependent on patient autonomy. Desloges et al[10] described 2 patients who developed symptomatic nonunion after nonoperative management. Although both patients were offered delayed TEA, only 1 patient accepted. The other patient had a history of metastatic colon cancer and was receiving chemotherapy at the time of acute DHF. She preferred to continue with nonoperative management as she felt that her symptoms were manageable and her function was adequate. Similarly, one patient who developed an extension malunion and subsequent bony impingement refused surgical release as he was otherwise pain free and content with his overall function.[10] These cases support the usefulness of PROMs and may be used by surgeons to set expectations and to provide patients with the information they need to make the most informed decisions regarding the totality of their treatment options.

The conclusions of this study are most limited by the quality of included studies. The risk of selection bias was high, and therefore, no meta-analysis was performed. Furthermore, each study failed to include uniform outcome reporting, and only nonsurgical treatment methodologies were included. Thus, direct comparisons against surgical outcomes cannot be made. In addition, it was assumed that all patients in this study were low demand. Although patients with a minimum of 65 years of age are often defined as elderly, there is little evidence to support the correlation of chronological age with functional ability.[27]

Conclusion

Nonoperative treatment of geriatric DHF can achieve satisfactory functional outcomes with little risk for complications or need for delayed surgery. Although surgical intervention may afford patients better functional outcomes, the risks of surgery and the likelihood of reoperation must be considered in low-demand elderly patients. The results from this study may be used by surgeons to provide patients with the information they need to make informed decisions regarding the totality of their treatment options.

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References

1. Aitken SA, Jenkins PJ, Rymaszewski L. Revisiting the 'bag of bones': functional outcome after the conservative management of a fracture of the distal humerus. Bone Joint J 2015;97-B:1132-8. https://doi.org/10.1302/0301-620X.97B8.35410.
2. Arora R, Lutz M, Deml C, Krappinger D, Haug L, Gabl M. A prospective randomized trial comparing nonoperative treatment with volar locking plate fixation for displaced and unstable distal radial fractures in patients sixty-five years of age and older. J Bone Joint Surg Am 2011;93:2146-53. https://doi.org/10.2106/JBJS.J.01597.
3. Batten TJ, Sin-Hidge C, Brinsden MD, Guyver PM. Non-operative management of distal humerus fractures in the elderly: a review of functional outcomes. Eur J Orthop Surg Traumatol 2018;28:23-7. https://doi.org/10.1007/s00590-017-2006-9.
4. Beks RB, Ochen Y, Frima H, Smeeing DPJ, van der Meijden O, Timmers TK, et al. Operative versus nonoperative treatment of proximal humeral fractures: a systematic review, meta-analysis, and comparison of observational studies and randomized controlled trials. J Shoulder Elbow Surg 2018;27:1526-34. https://doi.org/10.1016/j.jse.2018.03.009.
5. Brown RF, Morgan RG. Intercondylar T-shaped fractures of the humerus. Results in ten cases treated by early mobilisation. J Bone Joint Surg Br 1971;53:425-8.
6. Charissoux JL, Mabit C, Fourastier J, Beccari R, Emily S, Cappelli M, et al. Fractures articulaires complexes de l'extrémité distale de l'humérus chez le sujet âgé [Comminuted intra-articular fractures of the distal humerus in elderly patients]. Rev Chir Orthop Reparatrice Appar Mot 2008;94:S36-62. French. https://doi.org/10.1016/j.rco.2008.03.005.
7. Chen MJ, Campbell ST, Finlay AK, Duckworth AD, Bishop JA, Gardner MJ. Surgical and nonoperative management of olecranon fractures in the elderly. J Orthopaedic Trauma 2021;35:10-6. https://doi.org/10.1097/BOT.0000000000001865.
8. Cobb TK, Morrey BF. Total elbow arthroplasty as primary treatment for distal humeral fractures in elderly patients. J Bone Joint Surg Am 1997;79:826-32.
9. Cusick MC, Bonnaig NS, Azar FM, Mauck BM, Smith RA, Throckmorton TW. Accuracy and reliability of the mayo elbow performance score. J Hand Surg Am 2014;39:1146-50. https://doi.org/10.1016/j.jhsa.2014.01.041.
10. Desloges W, Faber KJ, King GJ, Athwal GS. Functional outcomes of distal humeral fractures managed nonoperatively in medically unwell and lower-demand elderly patients. J Shoulder Elbow Surg 2015;24:1187-96. https://doi.org/10.1016/j.jse.2015.05.032.
11. Eastwood WJ. The T-shaped fractures of the lower end of the humerus. J Bone Joint Surg 1937;19:364-9.
12. Egol K, Koval K, Zuckerman J. Distal Humerus. In: Handbook of Fractures. 6th edn. Philadelphia, PA: Wolters Kluwer Press; 2020. p. 213-29.
13. Galano GJ, Ahmad CS, Levine WN. Current treatment strategies for bicolumnar distal humerus fractures. J Am Acad Orthop Surg 2010;18:20-30. https://doi.org/10.5435/00124635-201001000-00004.
14. Githens M, Yao J, Sox AH, Bishop J. Open reduction and internal fixation versus total elbow arthroplasty for the treatment of geriatric distal humerus fractures: a systematic review and meta-analysis. J Orthop Trauma 2014;28:481-8. https://doi.org/10.1097/BOT.0000000000000050.
15. Goyal N, Bohl DD, Ong KL, Lau E, Nicholson GP, Wysocki RW. Reoperation risk after total elbow arthroplasty versus open reduction internal fixation for distal humerus fractures in elderly patients. J Orthop Trauma 2020;34:503-9. https://doi.org/10.1097/BOT.0000000000001767.
16. Gummesson C, Ward MM, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. BMC Musculoskelet Disord 2006;7:44. https://doi.org/10.1186/1471-2474-7-44.
17. Hartzler A, Pratt W. Managing the personal side of health: how patient expertise differs from the expertise of clinicians. J Med Internet Res 2011;13:e62. https://doi.org/10.2196/jmir.1728.
18. Jupiter JB, Neff U, Holzach P, Allgöwer M. Intercondylar fractures of the humerus. An operative approach. J Bone Joint Surg Am 1985;67:226-39.
19. Kozánek M, Bartoníček J, Chase SM, Jupiter JB. Treatment of distal humerus fractures in adults: a historical perspective. J Hand Surg Am 2014;39:2481-5. https://doi.org/10.1016/j.jhsa.2014.08.003.
20. Lauder A, Richard MJ. Management of distal humerus fractures. Eur J Orthop Surg Traumatol 2020;30:745-62. https://doi.org/10.1007/s00590-020-02626-1.
21. Linn MS, Gardner MJ, McAndrew CM, Gallagher B, Ricci WM. Is primary total elbow arthroplasty safe for the treatment of open intra-articular distal humerus fractures? Injury 2014;45:1747-51. https://doi.org/10.1016/j.injury.2014.07.017.
22. Logli AL, Shannon SF, Boe CC, Morrey ME, O'Driscoll SW, Sanchez-Sotelo J. Total elbow arthroplasty for distal humerus fractures provided similar outcomes when performed as a primary procedure or after failed internal fixation. J Orthop Trauma 2020;34:95-101. https://doi.org/10.1097/BOT.0000000000001631.
23. Lovy AJ, Keswani A, Koehler SM, Kim J, Hausman M. Short-term complications of distal humerus fractures in elderly patients: open reduction internal fixation versus total elbow arthroplasty. Geriatr Orthop Surg Rehabil 2016;7:39-44. https://doi.org/10.1177/2151458516630030.
24. Matheson LN, Melhorn JM, Mayer TG, Theodore BR, Gatchel RJ. Reliability of a visual analog version of the QuickDASH. J Bone Joint Surg Am 2006;88:1782-7. https://doi.org/10.2106/JBJS.F.00406.
25. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6:e1000097. https://doi.org/10.1371/journal.pmed.1000097.

26. Nestorson J, Ekholm C, Etzner M, Adolfsson L. Hemiarthroplasty for irreparable distal humeral fractures: medium-term follow-up of 42 patients. Bone Joint J 2015;97-B:1377-84. https://doi.org/10.1302/0301-620X.97B10.35421.
27. Ouchi Y, Rakugi H, Arai H, Akishita M, Ito H, Toba K, et al., Joint Committee of Japan Gerontological Society (JGLS) and Japan Geriatrics Society (JGS) on the definition and classification of the elderly. Redefining the elderly as aged 75 years and older: Proposal from the Joint Committee of Japan Gerontological Society and the Japan Geriatrics Society. Geriatr Gerontol Int 2017;17:1045-7. https://doi.org/10.1111/ggi.13118.
28. Palvanen M, Kannus P, Niemi S, Parkkari J. Secular trends in the osteoporotic fractures of the distal humerus in elderly women. Eur J Epidemiol 1998;14:159-64.
29. Phadnis J, Watts AC, Bain GI. Elbow hemiarthroplasty for the management of distal humeral fractures: current technique, indications and results. Shoulder Elbow 2016;8:171-83. https://doi.org/10.1177/1758573216640210.
30. Pidhorz L, Alligand-Perrin P, De Keating E, Fabre T, Mansat P. Société française de chirurgie orthopédique et traumatologie (SoFCOT). Distal humerus fracture in the elderly: does conservative treatment still have a role? Orthop Traumatol Surg Res 2013;99:903-7. https://doi.org/10.1016/j.otsr.2013.10.001.
31. Pooley J, Salvador Carreno J. Total elbow joint replacement for fractures in the elderly–Functional and radiological outcomes. Injury 2015;46:S37-42. https://doi.org/10.1016/j.injury.2015.08.011.
32. Prasad N, Dent C. Outcome of total elbow replacement for distal humeral fractures in the elderly: a comparison of primary surgery and surgery after failed internal fixation or conservative treatment. J Bone Joint Surg Br 2008;90:343-8. https://doi.org/10.1302/0301-620X.90B3.18971.
33. Santana MJ, Tomkins DJ. Patient-led use of patient-reported outcome measure in self-Management of a Rotator Cuff Injury. J Patient Rep Outcomes 2021;5:8. https://doi.org/10.1186/s41687-020-00283-w.
34. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg 2003;73:712-6. https://doi.org/10.1046/j.1445-2197.2003.02748.x.
35. Tomori Y, Nanno M, Takai S. Outcomes of nonsurgical treatment for transcondylar humeral fractures in adults: clinical results of nonoperative management. Medicine (Baltimore) 2019;98:e17973. https://doi.org/10.1097/MD.0000000000017973.
36. Welsink CL, Lambers KTA, van Deurzen DFP, Eygendaal D, van den Bekerom MPJ. Total elbow arthroplasty: a systematic review. JBJS Rev 2017;5:e4. https://doi.org/10.2106/JBJS.RVW.16.00089.
37. Werner BC, Rawles RB, Jobe JT, Chhabra AB, Freilich AM. Obesity is associated with increased postoperative complications after operative management of distal humerus fractures. J Shoulder Elbow Surg 2015;24:1602-6. https://doi.org/10.1016/j.jse.2015.04.019.
38. Wright RW, Brand RA, Dunn W, Spindler KP. How to write a systematic review. Clin Orthop Relat Res 2007;455:23-9. https://doi.org/10.1097/BLO.0b013e31802c9098.
39. Yetter TR, Weatherby PJ, Somerson JS. Complications of articular distal humeral fracture fixation: a systematic review and meta-analysis. J Shoulder Elbow Surg 2021;30:1957-67. https://doi.org/10.1016/j.jse.2021.02.017.
40. Zagorski JB, Jennings JJ, Burkhalter WE, Uribe JW. Comminuted intraarticular fractures of the distal humeral condyles. Surgical vs. nonsurgical treatment. Clin Orthop Relat Res 1986:197-204.