Management of giant cell tumor of the distal end radius: extended curettage and adjuvant therapy versus wide resection and reconstruction: a systematic review and meta-analysis

Hassan M.H. Eldebeis[a], Ayman M. El Masry[b], Mohamed A. Elmowafi[b]

[a]Department of Orthopedic Surgery, Nasser Institute, [b]Department of Orthopedic Surgery, Ain Shams University, Cairo, Egypt

Correspondence to Ayman M. El Masry, MD, Department of Orthopaedic Surgery, Faculty of Medicine, Ain Shams University, Abbassia Square, Cairo 11566, Egypt
Tel:+202-24821894;
e-mail: ayman_elmasry@med.asu.edu.eg

Received: 13-Jan-2024
Revised: 02-Feb-2024
Accepted: 19-Feb-2024
Published: 24-Jul-2024

The Egyptian Orthopaedic Journal 2024, 59:144–153

Background
Giant cell tumors (GCTs) in the distal end of the radius present unique challenges in balancing oncological clearance with preserving functional capabilities. This study aims to provide a comprehensive comparison between extended curettage with adjuvants and wide resection with reconstruction for GTCs of the distal radius, addressing outcomes such as recurrence rates, functional scores, and complications.

Patients and methods
A systematic review of the literature was conducted, involving databases such as MEDLINE, Cochrane library, and PubMed. Inclusion criteria comprised comparative cohort studies in English, comparing extended curettage with adjuvants versus wide resection with reconstruction in patients with GCTs of the distal end radius. Outcome measures included functional outcomes (Musculoskeletal Tumor Society, disabilities of the arm, shoulder, and hand), recurrence, metastasis, postoperative complications, and quality of life.

Results
The literature search identified 17 retrospective comparative cohort studies that met the inclusion criteria. The studies included 527 procedures, with an average participant age of 33.49 years and a mean follow-up of 7.1 years. The pooled estimate showed a significantly lower recurrence rate with wide resection (7.7%) compared with extended curettage with adjuvants (28.4%). Functional outcomes favored extended curettage in terms of visual analog scale pain scale and disabilities of the arm, shoulder, and hand score, with no significant difference in range of motion but higher grip strength in the curettage group. Complication rates were higher with wide resection.

Conclusion
While extended curettage with adjuvants may pose a higher risk of recurrence, it demonstrates promise for improved functional outcomes. The study suggests that extended curettage leads to reduced pain and disability scores compared with wide resection, with a higher grip strength. The findings contribute to the ongoing discussion on the optimal management of GCTs in the distal radius, highlighting the importance of balancing oncological considerations with functional outcomes. However, study limitations, including retrospective designs and potential selection bias, should be considered in interpreting the results.

Keywords:
extended curettage, giant cell tumor, meta-analysis, radius, wide resection

Egypt Orthop J 2024, 59:144–153

1110-1148

Introduction

Giant cell tumor (GCT) of the bone stands as a prevalent primary bone tumor, with a global incidence of ~6% [1]. The distal radius ranks as the third most frequent site for GCTs of the bone, following the distal femur and proximal tibia, constituting ~ 10–15% of cases [2]. The commonly used intralesional/simple curettage surgical technique exhibited recurrence rates surpassing 50% [3]. Consequently, advanced approaches such as extended curettage and wide resection were introduced, resulting in reduced recurrence rates ranging from 2 to 22%. The variance in failure rates is likely attributed to surgical techniques and the utilization of adjuvant therapy in the extended curettage procedure [4,5].

Previous research had pinpointed the distal radius as susceptible to repetition [2]. Elements contributing to this heightened recurrence percentage involve the anatomical shape of the distal radius, the complexity

 DOI: 10.4103/eoj.eoj_4_24

of the distal radioulnar joint, and the limited presence of the surrounding muscle. Moreover, the nearness of essential structures like the median nerve, radial artery, and flexor and extensor tendons poses a challenge in achieving broader margins [6,7].

Complete resection of the primary tumor plays a crucial role in local control to diminish the risk of recurrence and/or metastasis. Currently, the two main surgical treatments are extended curettage and wide resection. Managing the surgical treatment of distal end radius GCTs poses challenges, necessitating the mitigation of the risk of local recurrence while minimizing functional limitations postsurgery [8].

In spite of extensive removal displaying a decreased recurrence rate compared with curettage, the literature shows inconsistency regarding the overall functional outcome following either procedure [9,10]. Some surgeons support resection as a more assertive approach for GCTs, pointing to reduced function linked with the en bloc method. Conversely, others state that intralesional excision, along with various additional therapies, produces similar recurrence rates ranging from 0% to 28% [7]. Moreover, if prolonged curettage proves ineffective, alternative treatments such as en bloc resection followed by reconstruction are feasible. In additionally, repeated curettage has achieved local control in 89–100% of cases with recurrent GCTs in the distal radius [10].

This study aimed to objectively compare extended curettage and wide excision as definitive treatment modalities for distal end radius GCTs. The evaluation uses well-known oncological and functional scores to assess recurrence risk, metastatic rates, and various complications influencing the choice of surgical options for each patient.

Patients and methods

Literature search

The relevant studies were searched on PubMed, Google Scholar, The Cochrane Collaboration, ResearchGate, Scopus, and The New England Journal of Medicine using keywords distal radius, GCT of bone, resection, wrist en bloc resection, GCT, intralesional curettage, wrist fusion.

Eligibility criteria

We included studies that compared extended curettage with adjuvant versus wide resection in reconstruction in patients pathologically confirmed to have GCTs of the distal end radius eligible for surgery. The studies that could be included were randomized controlled trials and comparative cohort studies, both retrospective and prospective. We excluded case series, case reports, non-English studies, recurrent GCTs, nonoperatively treated patients, and those receiving chemotherapy or radiotherapy.

Outcome measures

Functional outcomes were reported by the Musculoskeletal Tumor Society (MSTS) that presented clinical and functional assessment based on six parameters including (pain, emotional acceptance, function acceptance, hand positioning, dexterity, lifting ability). The disabilities of the arm, shoulder, and hand (DASH) score is a 30-item self-report questionnaire designed to assess health status. It evaluates the degree of difficulty in performing physical activities, symptoms, and impact on social functioning. We also included data on survival rates, complications such as blood loss, wound infection, dislocation, implant failure, and quality of life.

Data extraction

Two reviewers conducted the data extraction process independently, ensuring a thorough and meticulous examination. The extracted data were subsequently subjected to a cross-checking procedure to enhance the reliability and accuracy of the information gathered.

Ethical considerations

Scientific and ethical approval were obtained from the Institutional Review Board. Patients signed informed consent regarding publishing their data and photographs.

Risk of bias assessment

The risk of bias in observational studies was evaluated using the Newcastle-Ottawa scale, considering participant selection, comparability, and outcome ascertainment [11].

Data synthesis

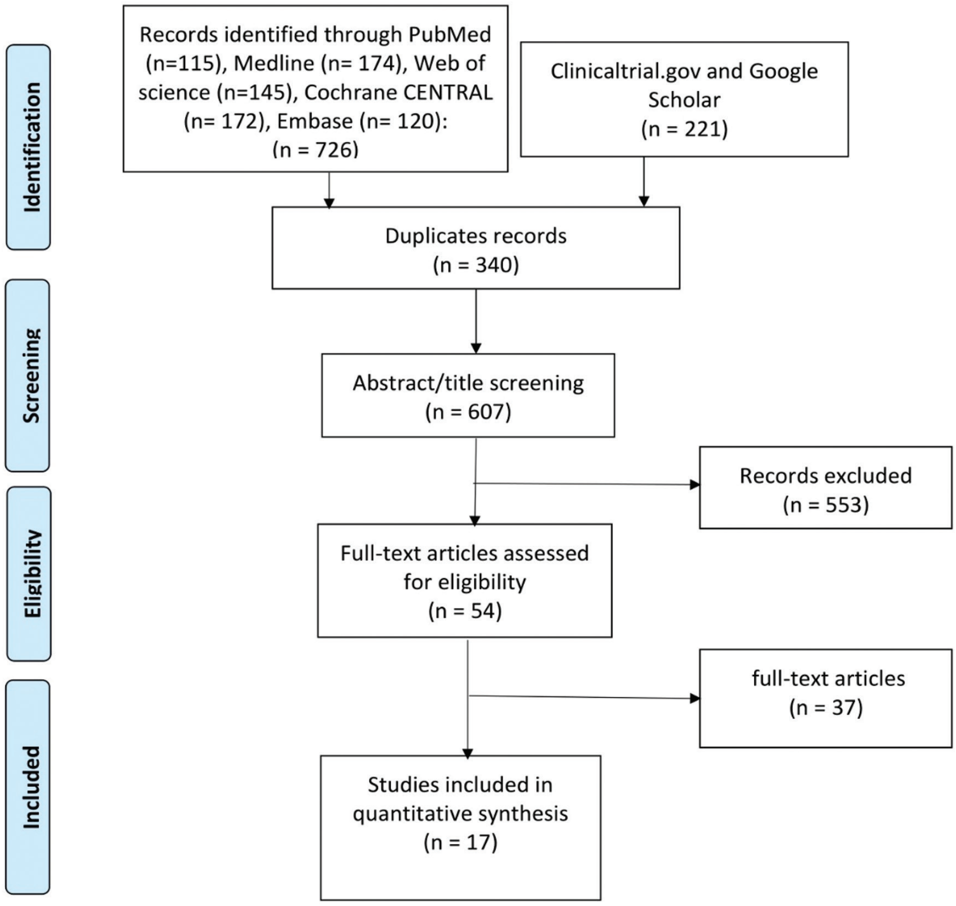
For dichotomous data, odds ratios (OR) with a 95% confidence interval (CI) were used. Mean differences (MD) with a 95% CI were used for continuous data. R software with the meta package was used for synthesis (https://www.r-project.org/). Heterogeneity was assessed through visual inspection, Q statistic, and I2 statistic. Sensitivity and subgroup analyses were conducted to identify sources of heterogeneity.

Results

Literature search results

Following a comprehensive literature search, we identified 607 unique records. Upon reviewing titles

Figure 1



PRISMA flow diagram of selection process.

and abstracts, 54 articles were thoroughly assessed for eligibility. Ultimately, 17 studies met our inclusion criteria, and the selection process is illustrated in Fig. 1 using a PRISMA flow diagram.

Characteristics of included studies

Seventeen retrospective comparative cohort studies [12-28] published between 1993 and 2022 were included in our final analysis. These studies examined 527 procedures, with participants averaging 33.49 years in age and a mean follow-up period of 7.1 years. Additional details about the studies, including the use of intraoperative adjuvants, defect filling methods after curettage, and types of reconstruction following resection, can be found in Table 1.

Risk of bias results

The overall risk of bias assessment showed a moderate to high risk of bias, with an overall quality ranging from low to moderate. The studies provided sufficient information about the representativeness of study participants and adequately described the identification and measurement of exposures and outcomes. The details of potential bias assessments are presented in Table 2.

Outcomes

Recurrence

The pooled estimate indicated a higher recurrence rate in the curettage group compared with the resection group [OR=3.48, 95% CI (2.02, 5.99), $P<0.01$], with no significant heterogeneity (I^2=22%, P=0.22) (Fig. 2).

Metastasis

The pooled estimate showed no significant difference in metastasis development between the two surgical approaches [OR=1.19, 95% CI (0.25, 5.61), P=0.83], with no significant heterogeneity (*I*2=0%, P=0.82) (Fig. 3).

Complications

The pooled estimate demonstrated a lower rate of complications in the curettage group compared with the resection group [OR=0.23, 95% CI (0.13, 0.38), $P<0.01$], with no significant heterogeneity (*I*2=0, P=0.45) (Fig. 4).

Visual analog score

Extended curettage was associated with a significant reduction in VAS pain scores compared with wide resection [MD=–1.43, 95% CI (–2.11, –0.74), $P<0.01$].

Table 1 Summary table of included studies

References	Number of patients	Age (years)	Males: femlaes	Follow-up (years)	Campanacci grade	Intraoperative adjuvants	Defect filled following curettage	Reconstruct following resection
van der Heijden *et al* [12].	77	NR	41: 35	8.8	NR	Phenol, PMMA, liquid nitrogen, soft-tissue extension	NR	#17 osteoarticular allograft, #9 primary arthrodesis, #2 fibula-pro-radius
Yadav *et al* [28].	32	29.5	12: 20	3.07	III: 18	High-speed burrs, electro-coagulation, and pulsatile lavage	Bone cement	NR
Kuruoglu *et al* [27].	24	42	12: 11	13	II: 14, III: 10	High-speed burring, phenol, hydrogen peroxide	Bone cement	NR
Jiao *et al* [13].	32	NR	13: 19	2.5	II: 11, III: 10	Microwave ablation	Bone cement filling	Non-vascularized autologous fibula reconstruction
Atalay [14]	20	28.6	6: 14		I: 1, II: 13, III: 2	Burring, ethanol	Autologous fibular graft, allogeneic bone graft segment, iliac graft or combinations	Allograft fibula+iliac autograft
Zou *et al* [15].	58	33.2	35: 23	7.9	NR	High-speed burring, iodine tincture, electrocautery	#9—PMMA cement #8—cancellous allograft #4—autograft	#26—fibular autograft #6—distal allograft #5—PMMA
Abuhejleh *et al* [16].	57	35.4	25: 32: 00	7.2	II = 13; III = 40a	Burring followed by inconsistent use of adjuvant and followed with jet wash	#23—bone cement #10—bone graft #1—empty	#7—vascularized fibular autografts #16—non-vascularized autograft
Mozaffarian *et al* [17].	13	33.7	6: 07	6	III = 13	High-speed burring	Bone cement	Proximal fibular autograft
Zhang *et al* [18].	20	34.8	NR	2.1	NR	95% ethanol was used to inactivate the tumor bed	Allogeneic bone graft/bone cement augmentation	Autologous fibular graft/ allogeneic bone graft
Wysocki *et al* [19].	39	34	22: 17	11.3	II=15; III=24	#20—Burr exteriorization #10—Phenol #12—Electrocautery #4—Argon beam #19—Polymethyl-methacrylate #1—Cancellous allograft	NR	#6—non-vascularized fibular autograft #3—Distal radius allograft #3—Ulnar transposition #3—Fibular allograft
Chanchairujira *et al* [20].	10	31	32: 42	3.2	NR	Cement or bone graft	NR	NR
Kang *et al* [21].	15	38	10: 05	5	III = 15	High-speed burring of the endosteal cavity, followed by irrigation, drying, and electrocautery coagulation ±liquid nitrogen	Antibiotic-laden PMMA cement	#5—Patients with vascularized or non-vascularized intercalary fibula autogenous graft arthrodesis #1—Total wrist arthroplasty/ allograft composite
Panchwagh *et al* [22].	24	36	13: 11	3.1	I=1; II = 9; III = 14	Phenol	#5—bone graft #4—Cement #2—no form of reconstruction	Proximal fibular graft wrist arthrodesis
Harness and Mankin [23]	46	31	NR	14	I=3; II=33; III=10	Burring or phenolization and insertion of PMMA	#5—Autograft #26—PMMA cement	NR
Cheng *et al* [24].	12	35	4: 08	6.8	III = 12	High-speed burr and phenol	#6—Autogenous cancellous bone graft, which was harvested from the iliac crest	#4—osteoarticular allograft #2—fibular autograft
Sheth *et al* [25].	26	34	12: 14	9	I=2; II = 8; III = 16	Liquid nitrogen	#9—bone graft #7—PMMA cement #2—no form of reconstruction	The selection of bone for arthrodesis varied from tibial cortex, tricortical iliac crest, ulna, or fibula
Vander Griend *et al* [26].	22	31.8	5: 17	5:03	NR	High-speed burn, combined more recently with pulsating lavage and electrocautery + PMMA	Packing with cement	#6—non-vascularized autogenous bone graft from the fibula #4—the adjacent ulna #1—the iliac crest

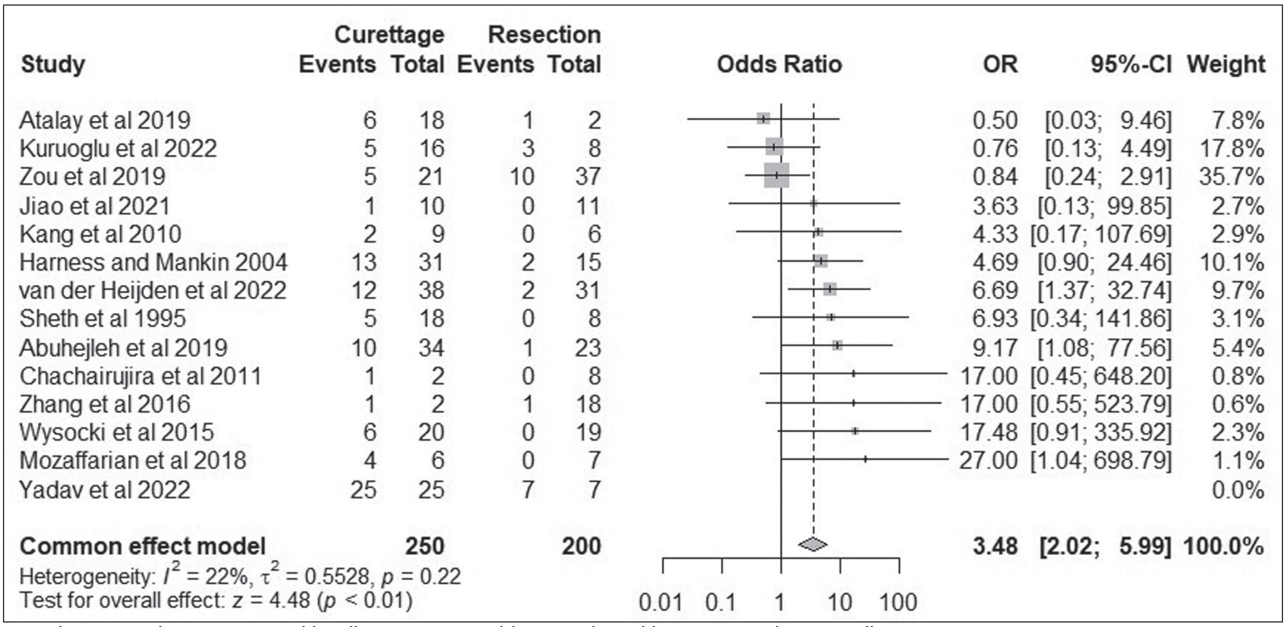
NR, not reported; PMMA, polymethyl-methacrylate.

Table 2 Quality assessment based on the Newcastle-Ottawa scale

References	Selection				Comparability	Exposure			Total[5]
	Representativeness of the exposed cohort	Selection of the nonexposed cohort	Ascertainment of exposure[1]	Outcome was not present at start of study	Control for 2 important factors[2,3]	Assessment of outcome	Follow-up long enough	Adequacy of follow-up of cohort[4]	
van der Heijden *et al* [12].	*	*	*	*	*	*	*	*	8
Yadav *et al* [28].	*	*	*	*	*	*	*	*	8
Kuruoglu *et al* [27].	*	*	*	*	*	*	*	*	8
Jiao *et al* [13].	*	*	-	*	*	*	*	*	7
Atalay [14]	*	*	*	*	*	*	*	*	8
Zou *et al* [15].	*	*	-	*	*	*	*	*	7
Abuhejleh *et al* [16].	*	*	*	*	*	*	*	*	8
Mozaffarian *et al* [17].	-	-	*	*	*	*	*	*	6
Zhang *et al* [18].	*	*	*	*	*	*	*	*	8
Wysocki *et al* [19].	*	*	*	*	*	*	*	*	8
Chanchairujira *et al* [20].	*	*	-	*	*	*	*	*	7
Kang *et al* [21].	*	*	*	*	*	*	*	*	8
Panchwagh *et al* [22].	*	*	*	*	*	*	*	*	8
Harness and Mankin [23]	*	*	-	*	*	*	*	*	7
Cheng *et al* [24].	*	*	*	*	-	*	*	*	7
Sheth *et al* [25].	*	*	*	*	*	*	*	*	8
Vander Griend *et al* [26].	*	*	-	*	*	*	*	*	7

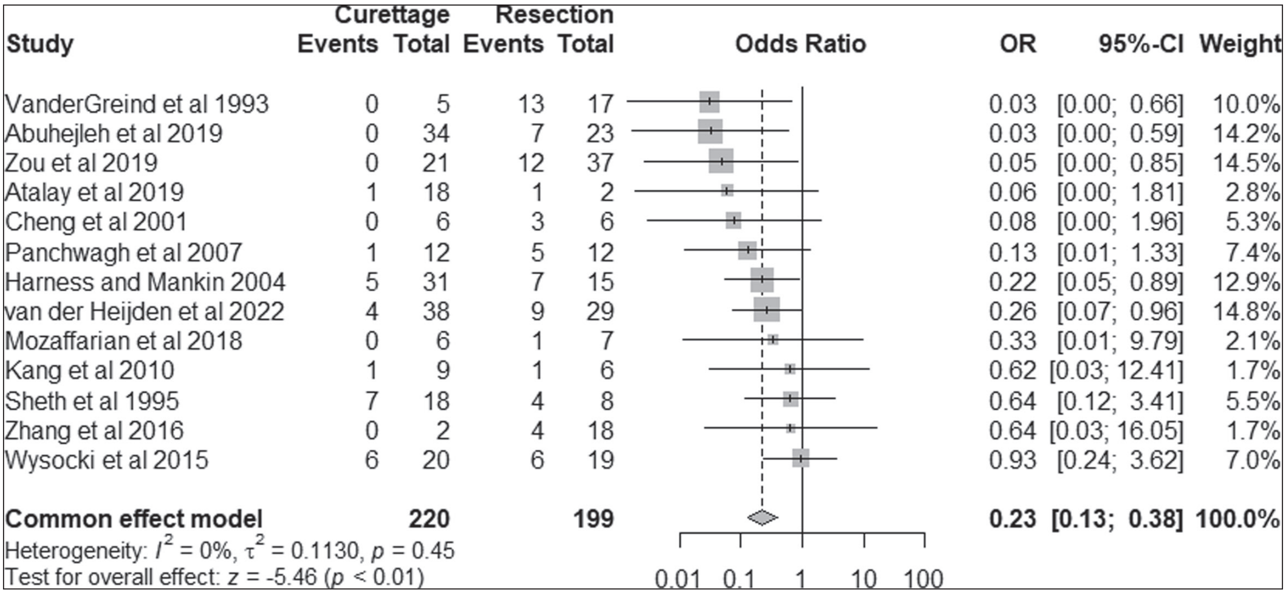
[1]In cases where the exposure information originated from a prescription database or medical record, a point was allocated.
[2]In instances where adjustment for age was performed, a point was designated.
[3]If adjustments were made for any other supplementary factors, a point was attributed.
[4]When the follow-up completeness reached 80% or exceeded, a point was granted.
[5]The Newcastle Ottawa scale is an 8-point score used to assess quality of nonrandomized studies and incorporate assessments in the interpretation of meta-analytic results. In this scale, 4 points are distributed on 'Selection' items, 1 point on 'Comparability' and 3 points on 'Outcome' items, as detailed on the table cells. This gives a maximum summation of 8.

Figure 2



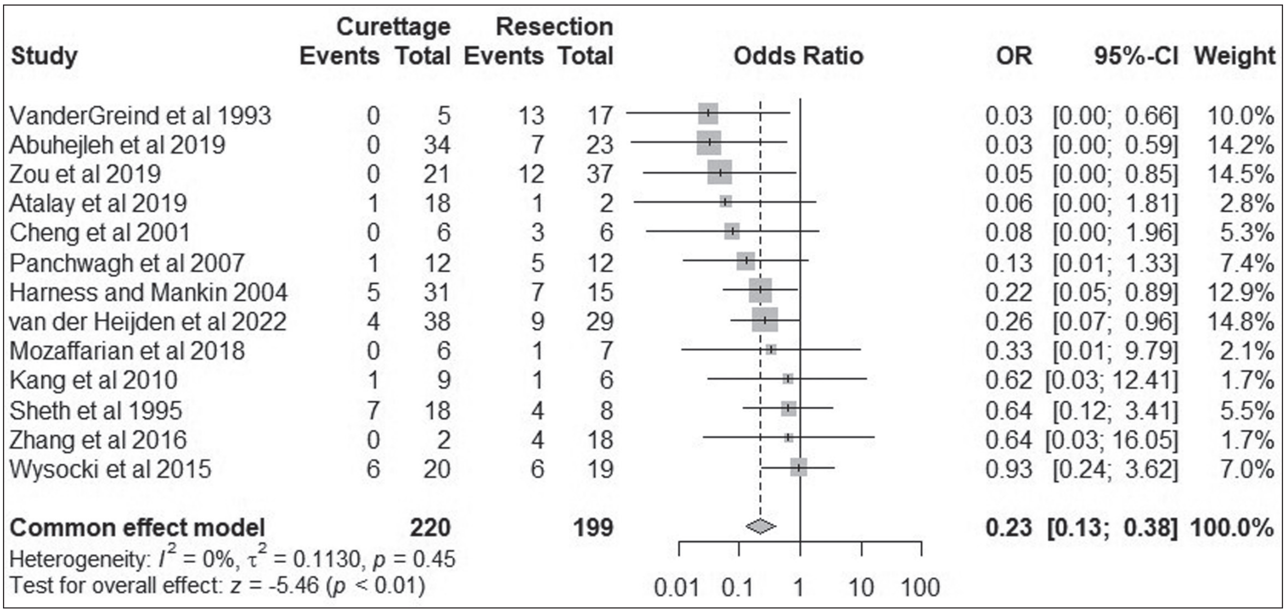
Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding recurrence rate.

Figure 3



Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding metastasis.

Figure 4



Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding complications.

Heterogeneity was observed in the analysis of VAS scores (*I*2=65%, *P*=0.09) (Fig. 5).

Disabilities of the arm, shoulder, and hand score

Patients who underwent extended curettage had significantly lower DASH scores compared with those who underwent wide resection [MD=−7.49, 95% CI (−9.62, −5.36), *P*<0.01], with no heterogeneity (*I*2=2%, *P*=0.36) (Fig. 6).

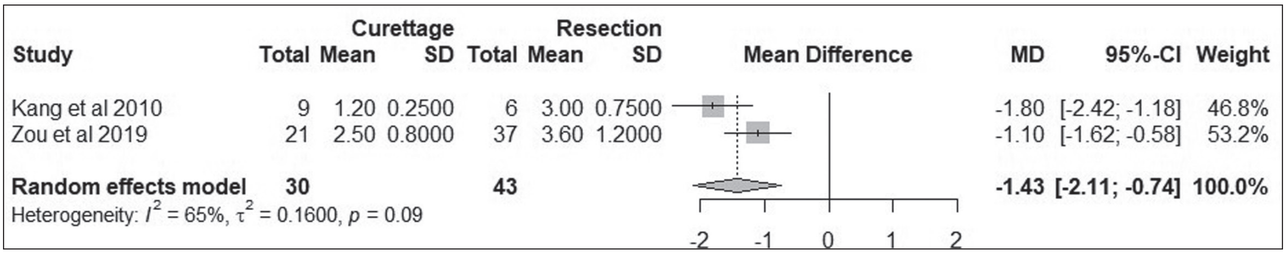
Range of motion

The pooled estimate showed no significant difference between groups in terms of flexion/extension and ulnar deviation/radial deviation. Heterogeneity was observed in pronation/supination [MD=−29.70, 95% CI (−44.15, 15.25)] (Fig. 7). It is worth noting that the mentioned comparison is between the group that had curettage and those who underwent wide resection with reconstruction using allograft/autograft without fusion with preservation of the joint mobility and reconstruction of the joint capsule.

Grip of strength

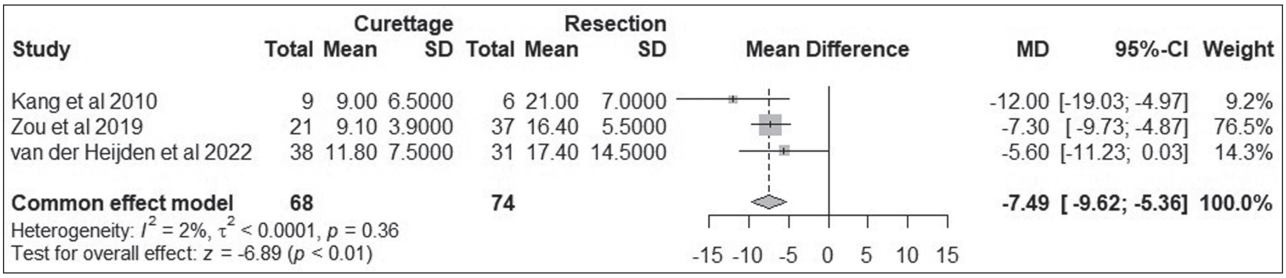
The pooled MD showed higher grip strength in the curettage group compared with the resection group

Figure 5



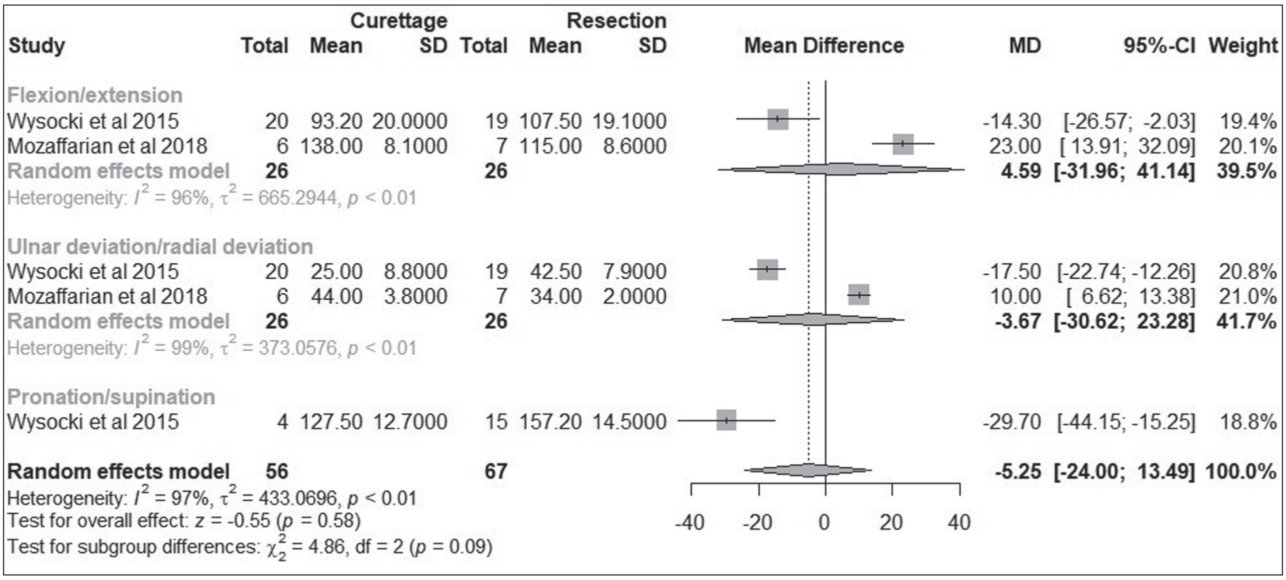
Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding VAS. VAS, visual analog scale.

Figure 6



Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding DASH. DASH, disabilities of the arm, shoulder, and hand.

Figure 7



Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding range of motion.

[MD=18.08, 95% CI (13.78, 22.37), P<0.01] with no heterogeneity ($I2$=0%, P=0.73) (Fig. 8).

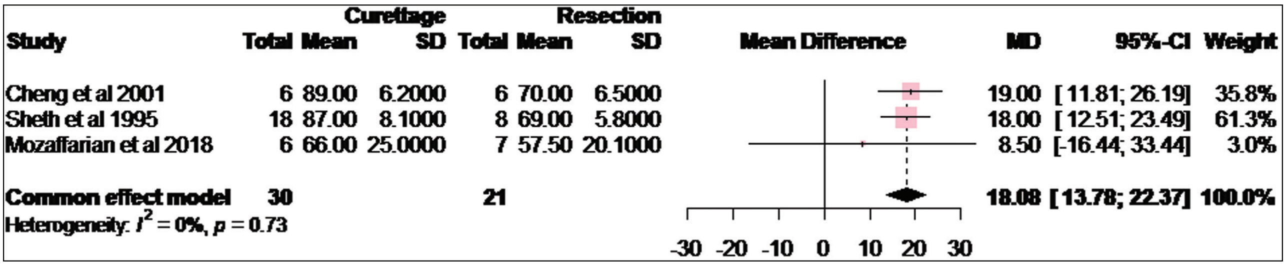
Musculoskeletal tumor society score

The curettage group was associated with significantly fewer poor or fair functional outcomes compared with the resection group [OR=0.34, 95% CI (0.14, 0.80), P<0.01], with moderate heterogeneity ($I2$=57%, P=0.10) (Fig. 9).

Discussion

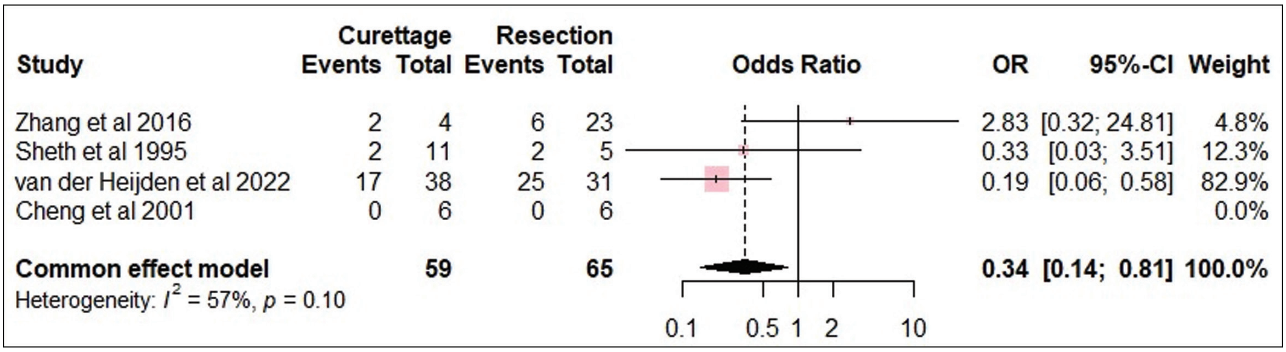
GCTs are prevalent neoplasms in the musculoskeletal system, known for their benign nature but with potential local aggressiveness and a small risk of pulmonary metastases [29]. Distal radius lesions, in particular, pose a higher risk of local recurrence due to anatomical factors. Managing GCTs in the distal radius is challenging, requiring a delicate balance between

Figure 8



Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding grip strength.

Figure 9



Forest plot comparing curettage with adjuvant versus wide resection with reconstruction regarding MSTS score. MSTS, Musculoskeletal Tumor Society.

Table 3 The Campanacci grading system [33]

Grade	Radiographic description
Grade 1 (quiescent)	Well-defined sclerotic margin intact cortex, slightly thinned out but not deformed
Grade 2 (active)	Well-defined margin without sclerosis cortex thinned out and expanded
Grade 3 (aggressive)	Ill-defined margin cortical destruction and soft-tissue extension

oncological clearance and preserving functional capabilities [19,30]. Previous meta-analyses have addressed the dilemma of choosing between curettage and wide resection, revealing that while curettage maintains wrist joint function, wide resection yields a lower recurrence rate, especially in Campanacci grade III tumors [30-32]. The Campanacci Grading system [33] is explained in Table 3.

In our study, we observed a significantly reduced recurrence rate with wide resection and reconstruction (7.7%) compared with extended curettage with adjuvants (28.4%). This aligns with earlier investigations. Grade III lesions should not automatically exclude curettage as a treatment option, as suggested by Cheng *et al.* [24] and Kang *et al.* [21]. However, Mozaffarian *et al.* [17] challenges this and recommends reserving curettage for grade I and II GCTs, citing high recurrence rates in their study. Our stance is that curettage remains suitable for grade I and II GCTs of the distal radius, considering their delayed clinical presentation and the compensatory functional capacity provided by the unaffected upper limb. Presently, acknowledged recurrence rates are 31–35% for extended curettage and 0–8% for wide resection [16,34].

Studies by Jalan *et al.* [30] and Pazionis *et al.* [31] demonstrated lower recurrence rates with wide excision compared with intralesional curettage. However, the presence of a grade III lesion should not rule out curettage as a treatment option. Our meta-analysis supports the idea that extended curettage leads to a significant reduction in VAS pain scale, DASH score, and poor or fair MSTS score compared with wide resection. Grip strength was higher in the curettage group, but no notable differences were observed in range of motion.

A review of 15 cases involving grade III GCTs of the distal radius showed that extended excision led to significantly improved grip strength and VAS scores compared with resection [20]. These results were corroborated by Cheng *et al.* [24], who observed similar outcomes in a comparison of curettage with wide resection and osteoarticular allograft in six patients each. Sheth *et al.* [25] reported comparable functional outcomes for both techniques. In a prospective assessment of 13 cases of distal radius GCTs, Mozaffarian *et al*. [17] found that patients undergoing wide resection retained acceptable ranges of motion, representing 83 and 92% of those in the curettage group, respectively. Similarly, Wysocki *et al*. [19] observed comparable MSTS scores between the excision and resection groups.

Complications associated with distal radius resection, such as nonunion, graft fracture, carpal subluxation, and degenerative arthritis, were higher in the wide resection group. Various graft alternatives and reconstruction techniques exist, each with its set of risks and benefits [35].

Strengths and limitations

This analysis is noteworthy for its thoroughness, encompassing a total of 17 studies, and for the absence of significant heterogeneity and publication bias. However, it is crucial to acknowledge certain limitations that merit discussion. First, the study is constrained in addressing inherent selection bias in the choice between resection and curettage, as resection might be the only feasible option for irreparable joints. It is plausible that, in the studies included, patients with more advanced disease and extensive bony destruction were directed toward resection. Second, all the studies incorporated in this analysis had a retrospective design, with a majority exhibiting a moderate to high risk of bias for most outcomes. Lastly, due to reporting inconsistencies across the included studies, the analysis could only compare pain scores and disability ratings in a small subset of the total studies.

Conclusion

While extended curettage with adjuvants may pose a higher risk of recurrence, it offers better functional outcomes. The meta-analysis showed that extended curettage was associated with reduced pain and disability scores compared with wide resection. While caution is warranted due to study limitations, these findings contribute to the ongoing discussion on the optimal management of GCTs in the distal radius.

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by all authors. The first draft of the manuscript was written by Dr Ayman M. El Masry, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Financial support and ssponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Çomunoğlu N, Kepil N, Dervişoğlu S. Histopathology of giant cell tumors of the bone: With special emphasis on fibrohistiocytic and aneurysmal bone cyst like components. Acta Orthop Traumatol Turc 2019; 53:35–39.

2 Wysocki RW, Soni E, Virkus WW, Scarborough MT, Leurgans SE, Gitelis S. Is intralesional treatment of giant cell tumor of the distal radius comparable to resection with respect to local control and functional outcome? Clin Orthop Relat Res 2015; 473:706–715.

3 Campbell WC, Canale ST, Beaty JH. Campbell's operative orthopaedics. 11th ed. Philadelphia, PA: Mosby/Elsevier Philadelphia, PA; 2008.

4 Becker WT, Dohle J, Bernd L, Braun A, Cserhati M, Enderle A, *et al*. Local recurrence of giant cell tumor of bone after intralesional treatment with and without adjuvant therapy. J Bone Joint Surg Am 2008; 90:1060–1067.

5 Koucheki R, Gazendam A, Perera J, Griffin A, Ferguson P, Wunder J, *et al*. Management of giant cell tumors of the distal radius: a systematic review and meta-analysis. Eur J Orthop Surg Traumatol 2023; 33: 759–772.

6 Sumari SN, Mat Zin NA, Wan Ismail WF, Islam MA. Global prevalence and risk of local recurrence following cryosurgery of giant cell tumour of bone: a meta-analysis. Cancers (Basel) 2022; 14:14.

7 Qu H, Guo W, Li D, Yang Y, Wei R, Xu J. Functional results of wrist arthrodesis versus arthroplasty with proximal fibula following giant cell tumour excision of the distal radius. J Hand Surg Eur Vol 2019; 44:394–401.

8 Salunke AA, Pathak S, Shah J, Pandit J, Naneria V. Wide resection versus curettage in giant cell tumor with pathological fracture? A systematic review and meta-analysis. J Clin Orthop Trauma 2018; 9(Suppl 1):S15–S18.

9 Lans J, Oflazoglu K, Lee H, Harness NG, Castelein RM, Chen NC, *et al*. Giant cell tumors of the upper extremity: predictors of recurrence. J Hand Surg Am 2020; 45:738–745.

10 van der Heijden L, Dijkstra PDS, Blay J-Y, Gelderblom H. Giant cell tumour of bone in the denosumab era. Eur J Cancer 2017; 77:75–83.

11 Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 2010; 25:603–605.

12 van der Heijden L, Bindt S, Scorianz M, Ng C, Gibbons M, van de Sande MAJ, *et al*. Surgical challenges, novel techniques, and systemic treatment of giant cell tumour of bone of the distal radius: clinical outcomes and systematic review of the literature. Bone & joint open 2022; 3:515–528.

13 Jiao YQ, Yang HL, Xu L, Liu J, Hu YC. Surgical treatment of distal radius giant cell tumors. Hand Surg Rrehabil 2021; 40:150–155.

14 Atalay İB, Öztürk R, Şimşek MA, Erdoğdu Yİ, Güngör BŞ. Giant cell tumors of bone localized in distal radius. Ann Clin Anal Med 2019; DOI: 10.4328/ACAM.20011.

15 Zou C, Lin T, Wang B, Zhao Z, Li B, Xie X, *et al*. Managements of giant cell tumor within the distal radius: A retrospective study of 58 cases from a single center. J Bone Oncol 2019; 14:100211.

16 Abuhejleh H, Wunder JS, Ferguson PC, Isler MH, Mottard S, Werier JA, *et al*. Extended intralesional curettage preferred over resection–arthrodesis for giant cell tumour of the distal radius. Eur J Orthop Surg Traumatol 2020; 30:11–17.

17 Mozaffarian K, Modjallal M, Vosoughi AR. Treatment of giant cell tumor of distal radius with limited soft tissue invasion: curettage and cementing versus wide excision. J Orthop Sci 2018; 23:174–179.

18 Zhang J, Li Y, Li D, Xia J, Li S, Yu S, *et al*. Clinical effects of three surgical approaches for a giant cell tumor of the distal radius and ulna. Mol Clin Oncol 2016; 5:613–617.

19 Wysocki RW, Soni E, Virkus WW, Scarborough MT, Leurgans SE, Gitelis S. Is intralesional treatment of giant cell tumor of the distal radius comparable to resection with respect to local control and functional outcome? Clin Orthop Relat Res 2015; 473:706–715.

20 Chanchairujira K, Jiranantanakorn T, Phimolsarnti R, Asavamongkolkul A, Waikakul S. Factors of local recurrence of giant cell tumor of long bone after treatment: plain radiographs, pathology and surgical procedures. J Med Assoc Thailand 2011; 94:1230–1237.

21 Kang L, Manoso MW, Boland PJ, Healey JH, Athanasian EA. Features of grade 3 giant cell tumors of the distal radius associated with successful intralesional treatment. J Hand Surg 2010; 35:1850–1857.

22 Panchwagh Y, Puri A, Agarwal M, Anchan C, Shah M. Giant cell tumor – distal end radius: do we know the answer? Indian J Orthop 2007; 41:139–145.

23 Harness NG, Mankin HJ. Giant-cell tumor of the distal forearm. J Hand Surg Am 2004; 29:188–193.

24 Cheng CY, Shih HN, Hsu KY, Hsu RW. Treatment of giant cell tumor of the distal radius. Clin Orthop Relat Res 2001; 383:221–228.

25 Sheth DS, Healey JH, Sobel M, Lane JM, Marcove RC. Giant cell tumor of the distal radius. J Hand Surg 1995; 20:432–440.

26 Vander Griend RA, Funderburk CH. The treatment of giant-cell tumors of the distal part of the radius. J Bone Jt Surg 1993; 75:899–908.

27 Kuruoglu D, Rizzo M, Rose PS, Moran SL, Houdek MT. Treatment of giant cell tumors of the distal radius: a long-term patient-reported outcomes study. J Surg Oncol 2022; 126:798–803.

28 Yadav U, Singla M, Sheoran A, Behera K, Garg A, Kundu ZS, *et al*. Recurrent giant cell tumour of distal end radius: treatment and outcomes after further surgeries. Cureus 2022; 14:e27451.

29 Turcotte RE. Giant cell tumor of bone. Orthop Clin N Am 2006; 37:35–51.

30 Jalan D, Gupta A, Nayar R, Aggarwal N, Singh K, Jain P. Curettage versus wide resection followed by arthrodesis/arthroplasty for distal radius giant cell tumours: a meta-analysis of treatment and reconstruction methods. J Orthop 2022; 33:15–24.

31 Pazionis TJ, Alradwan H, Deheshi BM, Turcotte R, Farrokhyar F, Ghert M. A systematic review and meta-analysis of en-bloc vs intralesional resection for giant cell tumor of bone of the distal radius. Open Orthop J 2013; 7:103–108.

32 Liu Y-P, Li K-H, Sun B-H. Which treatment is the best for giant cell tumors of the distal radius? A meta-analysis. Clin Orthop Rel Res 2012; 470:2886–2894.

33 Campanacci M, Baldini N, Boriani S, Sudanese A. Giant-cell tumor of bone. J Bone Joint Surg Am 1987; 69:106–114.

34 Puloski SK, Griffin A, Ferguson PC, Bell RS, Wunder JS. Functional outcomes after treatment of aggressive tumors in the distal radius. Clin Orthop Relat Res 2007; 459:154–160.

35 Seigerman D, Lutsky K, Fletcher D, Katt B, Kwok M, Mazur D, *et al*. Complications in the management of distal radius fractures: how do we avoid them?. Curr Rev Musculoskelet Med 2019; 12:204–212.