SCIENTIFIC ARTICLE

Wrist Ganglion Treatment: Systematic Review and Meta-Analysis

Linden Head, BsC, John Robert Gencarelli, BsC, Murray Allen, MD, Kirsty Usher Boyd, MD

Purpose To review the clinical outcomes of treatment for adult wrist ganglions and to conduct a meta-analysis comparing the 2 most common options: open surgical excision and aspiration.

Methods The review methodology was registered with PROSPERO. We performed a systematic search of MEDLINE and EMBASE for articles published between 1990 and 2013. Included studies reported treatment outcomes of adult wrist ganglions. Two independent reviewers performed screening and data extraction. We evaluated the methodological quality of randomized controlled trials (RCT) and cohort studies using the *Cochrane Handbook for Systematic Reviews* and the Newcastle-Ottawa Scale, respectively; Grading of Recommendations, Assessment, Development, and Evaluation was used to evaluate the quality of evidence.

Results A total of 753 abstracts were identified and screened; 112 full-text articles were reviewed and 35 studies (including 2,239 ganglions) met inclusion criteria for data extraction and qualitative synthesis. Six studies met criteria for meta-analysis, including 2 RCTs and 4 cohort studies. In RCTs surgical excision was associated with a 76% reduction in recurrence compared with aspiration. Randomized controlled trial quality was moderate. In cohort studies surgical excision was associated with a 58% reduction in recurrence compared with aspiration. Cohort study quality was very low. In cohort studies aspiration was not associated with a significant reduction in recurrence compared with reassurance. Across all studies mean recurrence for arthroscopic surgical excision (studies, 11; ganglions, 512), open surgical excision (studies, 14; ganglions, 809), and aspiration (studies, 12; ganglions, 489) was 6%, 21%, and 59%, respectively. Mean complication rate for arthroscopic surgical excision (studies, 6; ganglions, 221), open surgical excision (studies, 6; ganglions, 341), and aspiration (studies, 3; ganglions, 134) was 4%, 14%, and 3%, respectively.

Conclusions Open surgical excision offers significantly lower chance of recurrence compared with aspiration in the treatment of wrist ganglions. Arthroscopic excision has yielded promising outcomes but data from comparative trials are limited and have not demonstrated its superiority. Further RCTs are needed to increase confidence in the estimate of effect and to compare complications and recovery. *(J Hand Surg Am. 2015;40(3):546–553.*

Type of study/level of evidence Therapeutic I.

Key words Ganglion, meta-analysis, review, treatment, wrist.

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From the Faculty of Medicine, University of Ottawa; and the Division of Plastic Surgery, Ottawa Hospital, Ottawa, Ontario, Canada.

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Corresponding author: Kirsty Usher Boyd, MD, Division of Plastic Surgery, Ottawa Hospital, 1053 Carling Avenue, Box 213, Ottawa, Ontario K1Y 4E9, Canada; e-mail: kuboyd@gmail.com.

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GANGLIONS ARE THE MOST COMMON soft tissue masses of the hand and wrist.[1] Typically measuring 1 to 2 cm in size and either single or multiloculated, a ganglion may form suddenly or develop gradually.[2,3] Ganglions are thought to arise when repetitive microtrauma to the capsular and ligamentous structures of the joint stimulate fibroblasts at the synovial−capsule interface to produce hyaluronic acid.[4] A high concentration of hyaluronic acid and other mucopolysaccharides forms a clear, highly viscous fluid that pools in the ganglion.[4]

Indications for treatment include pain, stiffness, weakness, and appearance. Management of ganglions has been reported for centuries; according to Heister (1743), "a ganglion may often be happily dispersed by rubbing the tumor well each morning with fasting saliva and binding a plate of lead upon it for several weeks.… Others…prefer a bullet that has killed some wild creature, especially a stag. Sometimes, indeed, a recent ganglion will speedily vanish.… If none of these means prove effectual…they may be safely removed by incision."[5]

Currently, patients with wrist ganglions are typically educated and reassured regarding the mass and no further intervention is suggested, or they are offered either aspiration often combined with the injection of various substances, or surgical excision (either open or arthroscopic). All treatment modalities have widespread variability in reported recurrence and complication rates. The objectives of this study were to review recurrence and complication rates reported for modalities used to treat adult wrist ganglions and to generate a meta-analysis comparing the 2 most common options: open surgical excision and aspiration.

MATERIALS AND METHODS

Registration

The study protocol was registered with PROSPERO, an international prospective register of systematic reviews (CRD42014007441).

Literature search

To identify relevant publications, we searched MEDLINE and EMBASE, including studies from 1990 to December 2013. Only studies published since 1990 were included to ensure that findings reflected contemporary clinical practices, because recent studies have been unable to reproduce the low recurrence rates reported previously.[6] All key words related to treatment and prognosis of wrist ganglions were included, such as "wrist," "treatment," "ganglion," "aspiration," "excision," "arthroscopic," "recurrence," and "prognosis." The complete search strategy is available upon request.

A study was included if it met all of the following criteria: (1) the study population included adult patients with wrist ganglions, (2) recurrence or persistence of ganglions was a measured outcome, and (3) the study population had not previously received the treatment being investigated. Only English studies were considered and all reviews, case studies, response letters, and conference proceedings were excluded. Studies in which a portion of the study population met inclusion criteria were included if the results of the subpopulation were presented separately.

Study selection

Two independent reviewers applied the inclusion criteria to the references obtained from the literature search. Potential relevant studies were selected using the title and abstract retrieved from the literature search. We used a consensus method in cases of disagreement; a third author was not required to resolve any persistent disagreements.

Assessment of methodological quality and risk of bias

To evaluate the methodological quality of randomized controlled trials (RCT), we followed the *Cochrane Handbook for Systematic Reviews of Interventions* (domain-based evaluation).[7] Methodological quality of cohort studies was assessed using the Newcastle−Ottawa Scale (NOS) (maximum score of 9).[8] Risk of bias in case series was evaluated with a modified NOS (maximum score of 6).[8,9] Two authors independently scored the quality of each study. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system was used to record overall quality of evidence recurrence. The GRADE system summarizes evidence quality to grade evidence quality on a 4-point scale (very low to high). The system provides a transparent approach to assessing the quality of medical evidence, which has been adopted by several international organizations.[10−24]

Data extraction

Two reviewers independently extracted the data. Disagreements were discussed and a third review author was available for consultation if necessary. Extracted data included study characteristics (author, publication date, country, study design, and interventions), patient characteristics (number of participants, age, sex, ganglion location, and presenting symptoms), and outcomes (time to follow-up, recurrence, complications, and recovery).

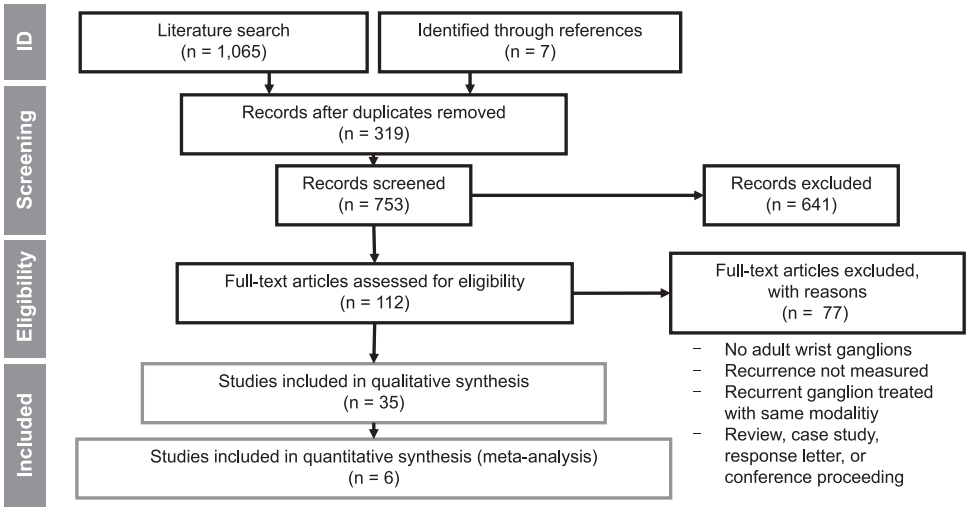

FIGURE 1: Flow diagram depicting the search strategy for inclusion of articles in the systematic review; reported in accordance with the Preferred Reporting Systems for Systematic Reviews and Meta-Analysis statement.

Data analysis

We performed meta-analysis with Revman software (Review Manager, version 5.1, The Cochrane Collaboration, 2011) using a random-effects model. Risk ratio was calculated as the effect measure to compare the probability of recurrence between treatment groups (eg, open surgical excision and aspiration). Effect size and a 95% confidence interval (CI) were calculated and displayed as forest plots. We assessed statistical heterogeneity using chi-square test with the level of significance at .05. Mean recurrence rates and complications rates were calculated for treatment modalities with more than 3 studies with reported data. The 95% confidence intervals were calculated using *t* distribution. The remaining data were described in a descriptive manner.

RESULTS

Study selection

Figure 1 shows a Preferred Reporting Systems for Systematic Reviews and Meta-analysis flow diagram depicting the study identification process. A total of 753 abstracts were identified from the literature search. Of those, 112 full-text articles were reviewed and 35 studies met inclusion criteria for data extraction and qualitative synthesis. There were 7 RCTs,[25–31] 6 cohort studies,[3,32–36] and 22 case series[37–58] within the 35 included studies. Two RCTs[25,26] and 4 cohort studies[3,32,33,35] were aligned with the study objective (compared open surgical excision and aspiration) and were included in the meta-analysis. The other 5 RCTs[27–31] and 2 cohort studies[34,36] investigated unique comparisons and could not be included for meta-analysis. Table 1 lists the total number of studies and ganglions investigated in each study design.

Quality assessment

Three RCTs had low risk of bias,[25,26,28] 3 had high risk,[27,29,30] and 1 was unclear.[31] The 3 RCTs with high risk of bias[27,29,30] all required downgrades because their sequence generation methodology used health record numbers. The 2 RCTs included for meta-analysis[25,26] had low risk of bias. Mean NOS score for cohort studies[3,32–36] was 8.2; the 4 cohort studies included in meta-analysis[3,32,33,35] had a mean NOS score of 8.0. Mean modified NOS score for case series[37–58] was 4.8. Appendices A to F (available on the *Journal's* Web site at www.jhandsurg.org) provide a complete summary of study quality.

Study populations

Within the 35 included studies[3,25–58] there were 2,239 ganglions. Individual study data can be found in Appendix G (available on the *Journal's* Web site at www.jhandsurg.org). Median reported female proportion was 68% (22 studies[3,25,26,28,30,32,34,36,38,40,42–45,47–49,53,54,56–58]). Ganglions were on the volar wrist 30% of the time (579 of 1,952), and dorsal, 70% (1,373 of 1,952) (28 studies[3,25–28,30–34,36,38,41–54,57,58]). Median reported age was 34 (range 23-45) (27 studies[3,25–28,30,32,33,36–38,40–49,51,53–55,57,58]); median reported follow-up was 32 months (range, 2–70 mo) (20 studies[3,32,33,35,38,40,42–44,46–52,54,55,57,58]). Median percent of patients presenting with pain, cosmetic concerns, and weakness were 71%, 34%, and 27%, respectively (14 studies[3,25,28,30,32,38,40,41,45,46,51,53,54,56]).

TABLE 1. Studies and Ganglions Included for Each Treatment Modality in This Systematic Review

	RCT, n		Cohort Study, n		Case Series, n		Total, n	
	Ganglions	Studies	Ganglions	Studies	Ganglions	Studies	Ganglions	Studies
Open surgical excision	90	4	384	5	335	5	809	14
Arthroscopic surgical excision	28	1	0	0	484	10	512	11
Aspiration with or without corticosteroid	167	4	235	5	87	3	489	12
Observation/reassurance	0	0	93	2	0	0	93	2
Aspiration plus multiple puncture with or without immobilization	93	2	0	0	0	0	93	2
Aspiration plus electrocautery	0	0	0	0	17	1	17	1
Aspiration plus fixation	0	0	0	0	66	2	66	2
Aspiration plus ethanol injection	0	0	22	1	0	0	22	1
Aspiration plus tetradecyl sulfate	0	0	0	0	33	1	33	1
Double dart technique*	0	0	105	1	0	0	105	1
Total	378		839		1,022		2,239	

*The double dart technique is a modification of aspiration and corticosteroid injection described by Paramhans et al.[34] A 16-gauge and 24-gauge needle are inserted concurrently into the ganglion facing each other. Ganglion content is aspirated through the 16-guage needle, and triamcinolone acetonide is injected via the previously placed 24-gauge needle once aspiration is complete.

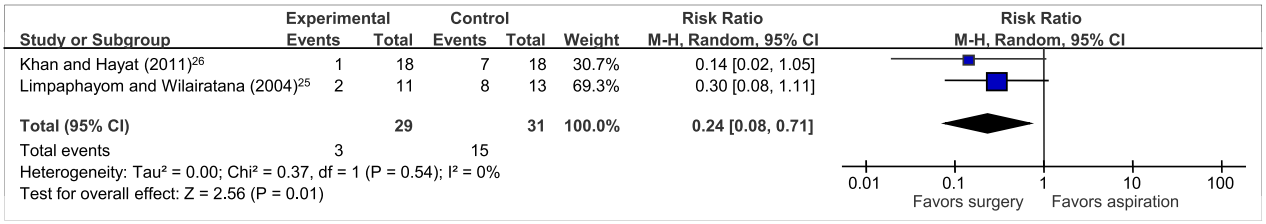

FIGURE 2: Forest plot of RCTs using random-effects model showing a significant reduction in ganglion recurrence with open surgical excision compared with aspiration.

Effectiveness of interventions

We performed meta-analyses using random-effects models out to compare recurrence rates between open surgical excision and aspiration and between aspiration and reassurance alone. We could not use a random-effects model to compare recurrence rates with arthroscopic surgical excision because only one comparative study[27] met inclusion criteria that investigated arthroscopic treatment.

Meta-analysis: recurrence in open surgical excision compared with aspiration with or without corticosteroid: Separate random-effects models were used to combine the RCTs[25,26] (Fig. 2) and cohort studies[3,32,33,35] (Fig. 3) that compared open surgical excision and aspiration. Within the 2 RCTs, surgical excision was associated with a 76% reduction in recurrence compared with aspiration ($P = .01$) and the test of heterogeneity was not significant ($P = .54$). The quality of RCT evidence was moderate (GRADE). Within the 4 cohort studies, surgical excision was associated with a 58% reduction in recurrence compared with aspiration ($P = .02$) and the test of heterogeneity was significant ($P < .001$). The quality of cohort evidence was very low (GRADE).

Meta-analysis: recurrence with aspiration with or without corticosteroid compared with reassurance: We used a random-effects model to combine cohort studies[3,32] that compared aspiration and reassurance alone (Fig. 4). Within the 2 cohort studies, there was no significant difference in recurrence between aspiration and reassurance ($P = .96$) and the test of heterogeneity was not significant ($P = .98$). The quality of cohort evidence was very low (GRADE).

Recurrence and complication rates

Across all study designs (RCT, cohort, and case series) mean recurrence rates (95% CI) for arthroscopic surgical excision (11 studies[27,38,41,46,49,51,52,54,55,57,58];

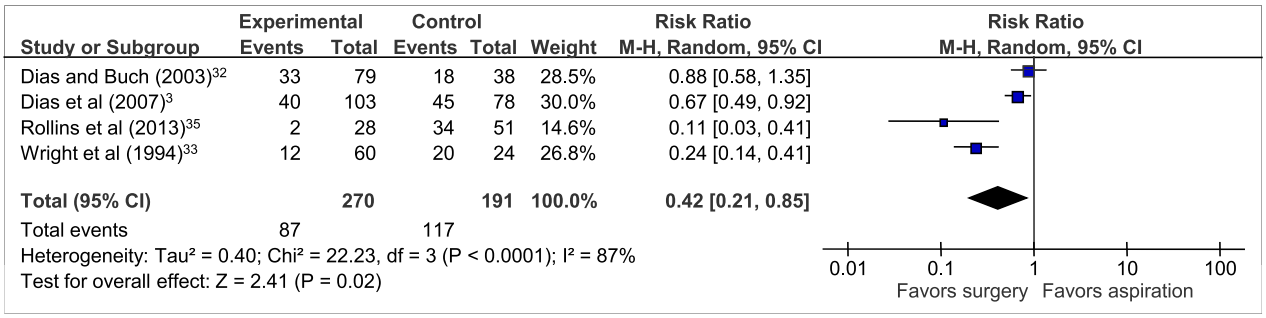

FIGURE 3: Forest plot of cohort studies using random-effects model showing a significant reduction in ganglion recurrence with open surgical excision compared with aspiration.

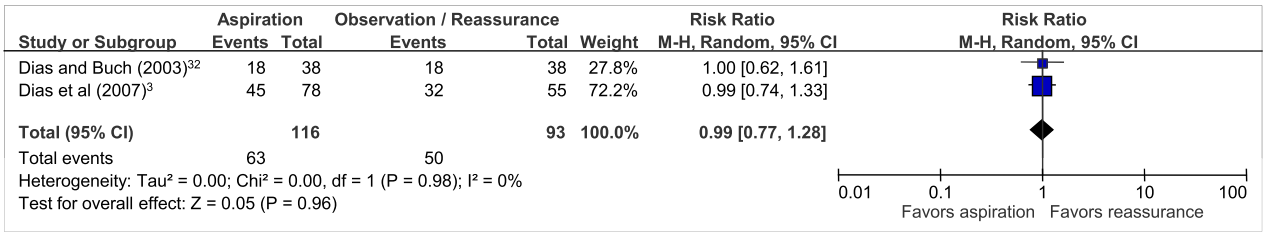

FIGURE 4: Forest plot of cohort studies using random-effects model showing no significant reduction in ganglion recurrence with aspiration compared with observation.

512 ganglions), open surgical excision (14 studies[3,25–28,32–35,40,42,44,45,48]; 809 ganglions), and aspiration (12 studies[3,25,26,29,30,32,33,35,36,39,47,50]; 489 ganglions) were 6% (2–10), 21% (13–28), and 59% (47–70), respectively. Mean complication rates (95% CI) for arthroscopic surgical excision (6 studies[27,38,51,54,55,58]; 221 ganglions), open surgical excision (6 studies[3,26,27,32,44,45]; 341 ganglions), and aspiration (3 studies[3,26,32]; 134 ganglions) were 4% (2–10), 14% (0–29), and 3% (−4 to 9), respectively. Complications included wound infection, neuroma, hypertrophic scar, neurapraxia, and radial artery damage. The number of studies indicated in parentheses is not mutually exclusive because a study may report recurrence or complication data for more than one treatment modality.

DISCUSSION

As the most common soft tissue mass of the hand and wrist, wrist ganglion treatments have been reported for centuries.[5] There are 3 general treatment approaches: observation, aspiration, and excision. Surgical intervention can be open or arthroscopic, with a number of recent studies reporting an arthroscopic approach.[27,38,39,51,54,55] Aspiration is often combined with some form of injection (eg, corticosteroid, ethanol, hyaluronidase), electrocautery, or multiple puncture.[3,25,26,29–37,39,43,47,50,53,56] Even for the most common treatment modalities, the literature has marked variability in outcomes. Furthermore, Gude and Morelli[6] noted that recent studies have been unable to reproduce the low recurrence rates reported previously. Focusing on literature since 1990, we sought to systematically review all treatment alternatives for adult wrist ganglions and to generate a meta-analysis for the most common treatment modalities.

Meta-analysis included 2 separate groups of studies: RCTs and cohort studies. Both study designs showed that open surgical excision was associated with significantly fewer recurrences compared with aspiration. Within the RCTs 2 were studies included,[25,26] and showed an overall 76% reduction in the incidence of recurrence. Both studies noted significant differences individually. The studies had low risk of bias (*Cochrane Collaboration's Handbook for Systematic Reviews*) and the overall quality was moderate (GRADE), requiring a single downgrade because of the small number of events. The cohort studies[3,32,33,35] showed a similar result, with surgical excision having a 58% reduction in recurrence compared with aspiration. This finding was in contrast with the findings of Dias and Buch[32] showing no difference between surgical excision and aspiration. The limitation in these 4 cohort studies was the high level of heterogeneity, which is

most likely attributable to selection bias, an inherent limitation in nonrandomized studies. The risk of bias of cohorts was low (NOS) but the overall quality of evidence was very low (GRADE) because it required downgrades for inconsistency and imprecision. Within the cohort studies, pooled risk ratios also showed that there was no difference in recurrence outcomes between aspiration and reassurance alone.[3,32]

Mean recurrence rates across all study designs were congruent with meta-analysis findings. Open surgical excision had a mean recurrence of 21%, compared with a recurrence rate of 59% for aspiration. Comparatively, Dias et al[3] and Dias and Buch[32] noted persistence rates of 47%[3] and 58%[32] in their study of palmar and dorsal ganglions, respectively. The lowest rate was observed with arthroscopic excision, with a recurrence of 6% across all studies. Insufficient RCT and cohort data were available for a meta-analysis of arthroscopic treatment compared with other treatment modalities, but an RCT by Kang et al[27] showed no difference in outcomes between arthroscopic and open excision at 12 months' follow-up.

Including the work by Kang et al,[27] 5 RCTs met inclusion criteria for qualitative analysis, but they were not included for meta-analysis because they involved unique comparisons. The study by Jagers et al[28] was the only RCT to show a difference between groups; it found that open surgical excision had significantly lower recurrence (24%) compared with aspiration and hyaluronidase injection (77%). Stephen et al[29] showed no difference in recurrence rates between groups receiving aspiration alone (32%) or aspiration combined with multiple puncture (22%). Korman et al[31] similarly found that adding immobilization after aspiration and multiple puncture (48%) had no impact on recurrence compared with no immobilization (50%). Varley et al[30] found a 67% recurrence rate after aspiration with or without corticosteroid injection.

There were insufficient data from RCTs to rigorously evaluate complication data, but complication incidences were pooled across studies. The highest complication incidence was seen with open surgical excision (14%), followed by arthroscopic excision (4%) and aspiration (2%). The small number of studies produced overlapping CIs across treatments. Complications reported in surgical excision were comparatively more serious than those reported with aspiration and included radial artery damage and neurapraxia. There were insufficient data for pooled analysis of postoperative recovery, but Dias et al[3] and Dias and Buch[32] reported 10 to 14 days off work after surgical excision, compared with 3 to 4 days for aspiration.

There are some limitations to this review and its conclusions. First, as a systematic review and meta-analysis, the strength of the conclusions depended on the quality of the studies included. Methodological quality was rigorously assessed with validated instruments and the studies included for meta-analysis had a low risk of bias; but there were a limited number of RCTs and the cohort studies showed significant heterogeneity. Second, the search was limited to studies published since 1990. Although represents the recurrence and complication rates seen in practice over the past 2 decades, it excludes earlier large case series such as that by Angelides and Wallace.[1] Third, although outcomes were grouped based on treatment modality, there were differences in methodology between studies within a given modality (eg, follow-up duration, surgical approach, postoperative immobilization). Fourth, patients receiving aspiration with or without corticosteroid injection were combined into one group because Varley et al[30] showed no significant difference between these 2 treatment groups. Fifth, ganglions were not differentiated based on anatomical location. Because of the structural differences between dorsal and volar ganglions,[4] considering them to be one entity might have introduced a confounding factor. Finally, this study was limited only to ganglions treated for the first time with a given modality and excluded recurrent ganglions treated more than once with the same approach.

This systematic review and meta-analysis shows that open surgical excision offers a significantly lower chance of recurrence compared with aspiration. Open surgical excision carries the risk of material complications. Aspiration is a simple option with a low risk of complications; but compared with reassurance alone, it does not appear to provide significant benefit with respect to ganglion resolution. Aspiration does, however, offer definitive confirmation of the diagnosis for the concerned patient or when ganglions are in atypical locations. Further RCTs could increase confidence in the estimate of effect and compare complications between treatments. Ultimately, treatment selection should be guided by the potential outcomes and complications of each treatment option as well as the patient's symptoms.

REFERENCES

1. Angelides A, Wallace P. The dorsal ganglia of the wrist: its pathogenesis, gross and microscopic anatomy, and surgical treatment. *J Hand Surg Am.* 1976;1(3):228–235.

2. Singh D, Culp RW. Arthroscopic ganglionectomy. *J Am Soc Surg Hand*. 2002;2(1):33–38.
3. Dias JJ, Dhukaram V, Kumar P. The natural history of untreated dorsal wrist ganglia and patient reported outcome 6 years after intervention. *J Hand Surg Eur Vol*. 2007;32(5):502–508.
4. Minotti P, Taras JS. Ganglion cysts of the wrist. *J Am Soc Surg Hand*. 2002;2(2):102–107.
5. Clay NR, Clement DA. The treatment of dorsal wrist ganglia by radical excision. *J Hand Surg Br*. 1988;13(2):187–191.
6. Gude W, Morelli V. Ganglion cysts of the wrist: pathophysiology, clinical picture, and management. *Curr Rev Musculoskel Med*. 2008;1(3-4):205–211.
7. Higgins J, Green S, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. Version 5. Available at: http://www.cochrane-handbook.org/. Accessed May 1, 2014.
8. 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(19):603–605.
9. Duggal A, Perez P, Golan E, Tremblay L, Sinuff T. Safety and efficacy of noninvasive ventilation in patients with blunt chest trauma: a systematic review. *Crit Care*. 2013;17:R142.
10. Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol*. 2011;64(4):383–394.
11. Guyatt GH, Oxman AD, Kunz R, et al. GRADE guidelines: 2. Framing the question and deciding on important outcomes. *J Clin Epidemiol*. 2011;64(4):395–400.
12. Balshem H, Helfand M, Schünemann HJ, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol*. 2011;64(4):401–406.
13. Guyatt GH, Oxman AD, Vist G, et al. GRADE guidelines: 4. Rating the quality of evidence—study limitations (risk of bias). *J Clin Epidemiol*. 2011;64(4):407–415.
14. Guyatt GH, Oxman AD, Montori V, et al. GRADE guidelines: 5. Rating the quality of evidence—publication bias. *J Clin Epidemiol*. 2011;64(12):1277–1282.
15. Guyatt GH, Oxman AD, Kunz R, et al. GRADE guidelines 6. Rating the quality of evidence—imprecision. *J Clin Epidemiol*. 2011;64(12):1283–1293.
16. Guyatt GH, Oxman AD, Kunz R, et al. GRADE guidelines: 7. Rating the quality of evidence—inconsistency. *J Clin Epidemiol*. 2011;64(12):1294–1302.
17. Guyatt GH, Oxman AD, Kunz R, et al. GRADE guidelines: 8. Rating the quality of evidence—indirectness. *J Clin Epidemiol*. 2011;64(12):1303–1310.
18. Guyatt GH, Oxman AD, Sultan S, et al. GRADE guidelines: 9. Rating up the quality of evidence. *J Clin Epidemiol*. 2011;64(12):1311–1316.
19. Brunetti M, Shemilt I, Pregno S, et al. GRADE guidelines: 10. Considering resource use and rating the quality of economic evidence. *J Clin Epidemiol*. 2013;66(2):140–150.
20. Guyatt G, Oxman AD, Sultan S, et al. GRADE guidelines: 11. Making an overall rating of confidence in effect estimates for a single outcome and for all outcomes. *J Clin Epidemiol*. 2013;66(2):151–157.
21. Guyatt GH, Oxman AD, Santesso N, et al. GRADE guidelines: 12. Preparing summary of findings tables—binary outcomes. *J Clin Epidemiol*. 2013;66(2):158–172.
22. Guyatt GH, Thorlund K, Oxman AD, et al. GRADE guidelines: 13. Preparing summary of findings tables and evidence profiles—continuous outcomes. *J Clin Epidemiol*. 2013;66(2):173–183.
23. Andrews J, Guyatt G, Oxman AD, et al. GRADE guidelines: 14. Going from evidence to recommendations: the significance and presentation of recommendations. *J Clin Epidemiol*. 2013;66(7):719–725.
24. Andrews JC, Schünemann HJ, Oxman AD, et al. GRADE guidelines: 15. Going from evidence to recommendation—determinants of a recommendation's direction and strength. *J Clin Epidemiol*. 2013;66(7):726–735.
25. Limpaphayom N, Wilairatana V. Randomized controlled trial between surgery and aspiration combined with methylprednisolone acetate injection plus wrist immobilization in the treatment of dorsal carpal ganglion. *J Med Assoc Thai*. 2004;87(12):1513–1517.
26. Khan PS, Hayat H. Surgical excision versus aspiration combined with intralesional triamcinolone acetonide injection plus wrist immobilization therapy in the treatment of dorsal wrist ganglion: a randomized controlled trial. *J Hand Microsurg*. 2011;3(2):55–57.
27. Kang L, Akelman E, Weiss AC. Arthroscopic versus open dorsal ganglion excision: a prospective, randomized comparison of rates of recurrence and of residual pain. *J Hand Surg Am*. 2002;33(4):471–475.
28. Jagers M, Akkerhuis O, Van Der Heijden M, Brink P. Hyaluronidase versus surgical excision of ganglia: a propsective, randomized clinical trial. *J Hand Surg Br*. 2002;27(3):256–258.
29. Stephen AB, Lyons AR, Davis TRC. A prospective study of two conservative treatments for ganglia of the wrist. *J Hand Surg Br*. 1999;24(1):104–105.
30. Varley G, Needoff M, Davis T, Clay R. Conservative management of wrist ganglia. *J Hand Surg Br*. 1997;22(5):636–637.
31. Korman J, Pearl R, Hentz VR. Efficacy of immobilization following aspiration of carpal and digital ganglions. *J Hand Surg Am*. 1992;17(6):1097–1099.
32. Dias J, Buch K. Palmar wrist ganglion: does intervention improve outcome? A prospective study of the natural history and patient-reported treatment outcomes. *J Hand Surg Br*. 2003;28(2):172–176.
33. Wright TW, Cooney WP, Ilstrup DM. Anterior wrist ganglion. *J Hand Surg Am*. 1994;19(6):954–958.
34. Paramhans D, Nayak D, Mathur RK, Kushwah K. Double dart technique of instillation of triamcinolone in ganglion over the wrist. *J Cutan Aesthet Surg*. 2010;3(1):29–31.
35. Rollins K, Ollivere B, Johnston P. Predicting successful outcomes of wrist and finger ganglia. *Hand Surg*. 2013;18(1):41–44.
36. Nasab SAM, Mashhadizadeh E, Sarrafan N. Comparative study between three methods of aspiration alone, aspiration plus steroid injection and aspiration plus ethanol injection for treatment of dorsal wrist ganglions. *Pakistan J Med Sci*. 2012;28(3):404–407.
37. Ajekigbe L, Stothard J. The effectiveness of sodium tetradecyl sulfate in treatment of wrist ganglia. *Can J Plast Surg*. 2006;14(1):28–30.
38. Aslani H, Najafi A, Zaaferani Z. Prospective outcomes of arthroscopic treatment of dorsal wrist ganglia. *Orthopedics*. 2012;35(3):e365–e370.
39. Breidahl WH, Adler RS. Ultrasound-guided injection of ganglia with coricosteroids. *Skeletal Radiol*. 1996;25(7):635–638.
40. Craik JD, Walsh SP. Patient outcomes following wrist ganglion excision surgery. *J Hand Surg Eur Vol*. 2012;37(7):673–677.
41. Edwards SG, Johansen JA. Prospective outcomes and associations of wrist ganglion cysts resected arthroscopically. *J Hand Surg Am*. 2009;34(3):395–400.
42. Faithfull DK, Seeto BG. The simple wrist ganglion-more than a minor surgical procedure? *Hand Surg*. 2000;5(2):139–143.
43. Gümüş N. A new sclerotherapy technique for the wrist ganglion: transcutaneous electrocauterization. *Ann Plast Surg*. 2009;63(1):42–44.
44. Gündeş H, Cirpici Y, Sarlak A, Müezzinoglu S. Prognosis of wrist ganglion operations. *Acta Orthop Belg*. 2000;66(4):363–367.
45. Jacobs L, Govaers K. The volar wrist ganglion: just a simple cyst? *J Hand Surg Br*. 1990;15(3):342–346.
46. Kim JP, Seo JB, Park HG, Park YH. Arthroscopic excision of dorsal wrist ganglion: factors related to recurrence and postoperative residual pain. *Arthrosc J Arthrosc Relat Surg*. 2013;29(6):1019–1024.
47. Korkmaz M, Ozturk H, Senarslan DA, Erdogan Y. Aspiration and methylprednisolone injection to the cavity with IV cannula needle in the treatment of volar wrist ganglia: new technique. *Pakistan J Med Sci*. 2013;29(1):5–8.

48. Lidder S, Ranawat V, Ahrens P. Surgical excision of wrist ganglia; literature review and nine-year retrospective study of recurrence and patient satisfaction. *Orthop Rev (Pavia)*. 2009;1(1):e5.
49. Mathoulin C, Hoyos A, Pelaez J. Arthroscopic resection of wrist ganglia. *Hand Surg*. 2004;9(2):159−164.
50. Muddu B, Morris M, Fahmy N. The treatment of ganglia. *J Bone Joint Surg Br*. 1990;72(1):147.
51. Osterman AL, Raphael J. Arthroscopic resection of dorsal ganglion of the wrist. *Hand Clin*. 1995;11(1):7−12.
52. Povlsen B, Tavakkolizadeh A. Outcome of surgery in patients with painful dorsal wrist ganglia and arthroscopic confirmed ligament injury: a five-year follow-up. *Hand Surg*. 2004;9(2):171−173.
53. Rathod C, Nemade A, Badole C. Treatment of dorsal wrist ganglia by transfixation technique. *Niger J Clin Pract*. 2011;14(4):445−448.
54. Rizzo M, Berger RA, Steinmann SP, Bishop AT. Arthroscopic resection in the management of dorsal wrist ganglions: results with a minimum 2-year follow-up period. *J Hand Surg Am*. 2004;29(1):59−62.
55. Rocchi L, Canal A, Pelaez J, Fanfani F, Catalano F. Results and complications in dorsal and volar wrist ganglia arthroscopic resection. *Hand Surg*. 2006;11(1-2):21−26.
56. Singhal R, Angmo N, Gupta S, Kumar V, Mehtani A. Ganglion cysts of the wrist: a prospective study of a simple outpatient management. *Acta Orthop Belg*. 2005;71(5):528−534.
57. Shih J-T, Hung S-T, Lee H-M, Tan C-M. Dorsal ganglion of the wrist: results of treatment by arthroscopic resection. *Hand Surg*. 2002;7(1):1−5.
58. Yamamoto M, Kurimoto S, Okui N, Tatebe M, Shinohara T, Hirata H. Sonography-guided arthroscopy for wrist ganglion. *J Hand Surg Am*. 2012;37(7):1411−1415.

APPENDIX A. Methodological Quality of Randomized Controlled Trials

Study	Overall Risk of Bias	Sequence Generation	Allocation Concealment	Blinding of Participants, Personnel, and Outcome Assessors to Study Protocol	Incomplete Outcomes Data	Selective Outcomes Reporting	Other Sources of Bias
Jagers et al (2002)[28]	Low	Low	Unclear	Low	Low	Low	Low
Kang et al (2002)[27]	High	High	High	Low	Low	Low	Low
Khan and Hayat (2011)[26]	Low	Low	Unclear	Low	Low	Low	Low
Korman et al (1992)[31]	Unclear	Unclear	Unclear	Low	Unclear	Low	Unclear
Limpaphayom and Wilairatana (2004)[25]	Low	Low	Unclear	Low	Low	Low	Low
Stephen et al (1999)[29]	High	High	High	Low	Low	Low	High
Varley et al (1997)[30]	High	High	High	Low	Low	Low	High

APPENDIX B. Methodological Quality of Cohort Studies Evaluated Using Newcastle–Ottawa Scale

	Selection				Comparability	Outcome		
Study	Representativeness of Cohort	Selection of Non-exposed Cohort	Ascertainment of Exposure	Demonstration That Outcome of Interest Was Not Present at Start of Study	Comparability of Cohorts on Basis of Design or Analysis Time to Follow-Up	Assessment of Outcome	Follow-Up Long Enough for Outcomes to Occur	Adequacy of Follow-Up Cohorts
Dias et al (2007)[3]	1	1	1	1	2	0	1	1
Dias and Buch (2003)[32]	1	1	1	1	2	0	1	1
Nasab et al (2012)[36]	1	1	1	1	2	1	1	0
Paramhans et al (2010)[34]	1	1	1	1	2	1	1	1
Rollins et al (2013)[35]	1	1	1	1	1	1	1	1
Wright et al (1994)[33]	1	1	1	1	2	0	1	1

APPENDIX C. Methodological Quality of Case Series Evaluated Using Modified Newcastle–Ottawa Scale

	Selection				Comparability	Outcome		
Study	Representativeness of Cohort	Selection of Non-exposed Cohort	Ascertainment of Exposure	Demonstration That Outcome of Interest Was Not Present at Start of Study	Comparability of Cohorts on Basis of Design or Analysis Time to Follow-Up	Assessment of Outcome	Follow-Up Long Enough for Outcomes to Occur	Adequacy of Follow-Up Cohorts
Ajekigbe and Stothard (2006)[37]	1	N/A	1	1	N/A	0	1	1
Aslani et al (2012)[38]	1	N/A	1	1	N/A	1	1	0
Breidahl and Adler (1996)[39]	1	N/A	1	1	N/A	0	0	0
Craik and Walsh (2012)[40]	1	N/A	1	1	N/A	0	1	1
Edwards and Johansen (2009)[41]	0	N/A	1	1	N/A	1	1	1
Faithfull and Seeto (2000)[42]	1	N/A	1	1	N/A	1	1	1
Gümüş (2009)[43]	1	N/A	1	1	N/A	1	1	0
Gündeş et al (2000)[44]	1	N/A	1	1	N/A	1	1	1
Jacobs and Govaers (1990)[45]	1	N/A	1	1	N/A	1	0	1
Kim et al (2013)[46]	1	N/A	1	1	N/A	1	1	1
Korkmaz et al (2013)[47]	0	N/A	1	1	N/A	1	1	0
Lidder et al (2009)[48]	1	N/A	1	1	N/A	0	1	1
Mathoulin et al (2004)[49]	0	N/A	1	1	N/A	1	1	0
Muddu et al (1990)[50]	0	N/A	1	1	N/A	1	1	0
Osterman and Raphael (1995)[51]	0	N/A	1	1	N/A	1	1	1
Povlsen and Tavakkolizadeh (2004)[52]	1	N/A	1	1	N/A	0	1	1
Rathod et al (2011)[53]	0	N/A	1	1	N/A	1	1	0
Rizzo et al (2004)[54]	1	N/A	1	1	N/A	0	1	1
Rocchi et al (2006)[55]	1	N/A	1	1	N/A	1	0	0
Singhal et al (2005)[56]	1	N/A	1	1	N/A	1	1	0
Shih et al (2002)[57]	1	N/A	1	1	N/A	0	1	1
Yamamoto et al (2012)[58]	1	N/A	1	1	N/A	1	1	0

N/A, not available.

APPENDIX D. Grading of Recommendations Assessment, Development, and Evaluation of Overall Quality of Recurrence Evidence for RCTs Comparing Open Surgical Excision and Aspiration

Randomized Controlled Trials

Population: adult wrist ganglions
Intervention: open surgical excision
Comparison: aspiration with or without corticosteroid
Outcome: recurrence
Quality of evidence: moderate (starting point: high)

	Risk of Bias (Cochrane)	Inconsistency	Indirectness	Imprecision	Publication Bias
Overall	No serious limitations	No serious limitations	No serious limitations	Serious limitations	No serious limitations
Comment	Unclear concealment but all other dimensions had low risk of bias	Overlapping CIs Low heterogeneity: $I^2 = 0\%$ ($P = .54$)	Aligned with PICO of interest (adults with ganglion [P], surgery [I], aspiration [C], recurrence [O])	Total number of events < 300 CIs for estimates do not include both appreciable benefit and harm (only indicate benefit)	There are a small number of RCTs (but more including cohorts) No finding is immaterial; a finding of no difference is an important clinical finding There are many studies published in this field with "no significant difference between groups"
Downgrade	No downgrade	No downgrade	No downgrade	Downgrade 1 level	No downgrade
Khan and Hayat (2011)[26]	Low risk of bias				
Limpaphayom and Wilairatana (2004)[25]	Low risk of bias				

PICO, population, intervention, comparison, outcomes.

APPENDIX E. Grading of Recommendations Assessment, Development, and Evaluation of Overall Quality of Recurrence Evidence for Cohort Studies Comparing Open Surgical Excision and Aspiration

Cohort Studies

Population: adult wrist ganglions
Intervention: open surgical excision
Comparison: aspiration with or without corticosteroid
Outcome: recurrence
Quality of evidence: very low (starting point: low)

	Risk of Bias (NOS)	Inconsistency	Indirectness	Imprecision	Publication Bias
Overall	No serious limitations	Serious limitations	No serious limitations	Serious limitations	No serious limitations
Comment	Mean NOS of 8.0	Not all CIs overlap High heterogeniety: $I^2 = 87\%$ ($P < .001$)	Aligned with PICO of interest (adults with ganglion [P], surgery [I], aspiration [C], recurrence [O])	Total number of events < 300 CIs for estimates do not include both appreciable benefit and harm (only indicate benefit)	No finding is immaterial; a finding of no difference is an important clinical finding There are many studies published in this field with "no significant difference between groups"
Downgrade	No downgrade	Downgrade 1 level	No downgrade	Downgrade 1 level	No downgrade
Dias and Buch (2003)[32]	Low risk of bias				
Dias et al (2007)[3]	Low risk of bias				
Rollins et al (2013)[35]	Low risk of bias				
Wright et al (1994)[33]	Low risk of bias				

PICO, population, intervention, comparison, outcomes.

APPENDIX F. Grading of Recommendations Assessment, Development, and Evaluation of Overall Quality of Recurrence Evidence for Cohort Studies Comparing Aspiration and Reassurance

Cohort Studies

Population: adult wrist ganglions
Intervention: aspiration with or without corticosteroid
Comparison: reassurance
Outcome: recurrence
Quality of evidence: very low (starting point: low)

	Risk of Bias (NOS)	Inconsistency	Indirectness	Imprecision	Publication Bias
Overall	No serious limitations	Serious limitations	No serious limitations	Serious limitations	No serious limitations
Comment	Mean NOS of 8.0	All CIs overlap Low heterogeneity: $I^2 = 0\%$ ($P = .98$)	Aligned with PICO of interest (adults with ganglion [P], aspiration [I], reassurance [C], recurrence [O])	Total number of events < 300 CIs for estimates do not include both appreciable benefit and harm (only indicate benefit)	No finding is immaterial; a finding of no difference is an important clinical finding There are many studies published in this field with "no significant difference between groups"
Downgrade	No downgrade	No downgrade	No downgrade	Downgrade 1 level	No downgrade
Dias and Buch (2003)[32]	Low risk of bias				
Dias et al (2007)[3]	Low risk of bias				

PICO, population, intervention, comparison, outcomes.

APPENDIX G. Study Characteristics for All 35 Included Studies

Study	Study Characteristics			Presenting Symptoms			Arthroscopic Surgical Excision		Open Surgical Excision		Aspiration With or Without Corticosteroid		Observation/ Reassurance		Other	
	Ganglions, n	Age (mean)	Follow-Up (mean)	Pain (%)	Weakness (%)	Cosmesis (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)
Ajekigbe and Stothard (2006)[37]	33	35.2													36.4	
															Aspiration plus tetradecyl sulfate	
Aslani et al (2012)[38]	52	29.8	39.2	71.2			17.0	13.5								
Breidahl and Adler (1996)[39]	7										71.0					
Craik and Walsh (2012)[40]	48	39.0	44.0	79.2	70.8				8.0							
Dias and Buch (2003)[32]	155	45.1	63.0	86.1	25.8	33.8			42.0	20.3	47.0	5.3	47.0	0.0		
Dias et al (2007)[3]	236	36.3	70.4	58.5	20.3	27.1			39.0	7.8	58.0	2.6	58.0	0.0		
Edwards and Johansen (2009)[41]	45	42.0		87.3		12.7	0.0									
Faithfull and Seeto (2000)[42]	59	38.0	65.0						10.0							
Gümüş (2009)[43]	17	32.7	17.0												5.9	0.0
															Aspiration plus electrocautery	
Gündeş et al (2000)[44]	40	30.2	27.0						18.0	30.0						
Jacobs and Govaers (1990)[45]	71	35.0		72.9		60.0			28.0	28.6						
Jagers et al (2002)[28]	38	39.4		75.3	28.1				29.0							
Kang et al (2002)[27]	51	34.9					11.0	2.4	9.0	0.0						
Khan and Hayat (2011)[26]	36	31.0							6.0	0.0	39.0	0.0				
Kim et al (2013)[46]	98	34.0	32.0	70.3			12.0									
Korkmaz et al (2013)[47]	19	27.6	25.2								16.0					
Korman et al (1992)[31]	52														53.8	
															Aspiration plus multiple puncture with or without immobilization	

(Continued)

APPENDIX G. Study Characteristics for All 35 Included Studies (Continued)

Study	Study Characteristics			Presenting Symptoms			Arthroscopic Surgical Excision		Open Surgical Excision		Aspiration With or Without Corticosteroid		Observation/ Reassurance		Other	
	Ganglions, n	Age (mean)	Follow-Up (mean)	Pain (%)	Weakness (%)	Cosmesis (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)
Lidder et al (2009)[48]	117	41.5	50.4						42.0							
Limpaphayom and Wilairatana (2004)[25]	24	31.0		58.3	8.3	4.2			18.0		62.0					
Mathoulin et al (2004)[49]	128	39.3	32.0				3.0									
Muddu et al (1990)[50]	61		2.1								69.0					
Nasab et al (2012)[36]	66	29.2									55.0				36.4	
															Aspiration plus ethanol injection	
Osterman and Raphael (1995)[51]	18	23.0	16.0	66.7	55.6	77.8	0.0	0.0								
Paramhans et al (2010)[34]	219								12.0						7.6	
															Double dart technique	
Povlsen and Tavakkolizadeh (2004)[52]	8		64.0				0.0									
Rathod et al (2011)[53]	40	25.0		50.0		87.5									2.5	5.0
															Aspiration plus fixation	
Rizzo et al (2004)[54]	41	29.8	47.8	100.0			5.0	0.0								
Rocchi et al (2006)[55]	40	32.0	15.0				5.0	8.5								
Rollins et al (2013)[35]	79		32.0						7.0		67.0					
Shih et al (2002)[57]	32	23.7	26.8				0.0									
Singhal et al (2005)[56]	26			46.2		34.6									50.0	
															Aspiration plus fixation	

(Continued)

APPENDIX G. Study Characteristics for All 35 Included Studies (Continued)

Study	Study Characteristics			Presenting Symptoms			Arthroscopic Surgical Excision		Open Surgical Excision		Aspiration With or Without Corticosteroid		Observation/ Reassurance		Other	
	Ganglions, n	Age (mean)	Follow-Up (mean)	Pain (%)	Weakness (%)	Cosmesis (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)	R (%)	C (%)
Stephen et al (1999)[29]	92										69.0				78.0 Aspiration plus multiple puncture with or without immobilization	
Varley et al (1997)[39]	85	36.5		70.6							68.0					
Wright et al (1994)[33]	84	43.0	60.0						20.0		83.0					
Yamamoto et al (2012)[58]	22	34.0	21.0				9.0	0.0								

R (%), recurrence rate; C (%), complication rate.