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Arthroscopic Versus Open Excision of Wrist Ganglion Cysts: A Comprehensive Systematic Review and Meta-Analysis of 7233 Cases

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Abstract

Introduction:

Ganglion cysts are the most common benign hand and wrist masses, with surgical excision often required when symptomatic. This systematic review and meta-analysis reported and compared recurrence and complication rates between arthroscopic and open excision of wrist ganglion cysts.

Methods

A comprehensive search was conducted across multiple databases, and eligible studies included randomized controlled trials, cohort studies, and case series with a minimum of 10 patients. Data on recurrence, complications, and patient-reported outcomes were extracted and analyzed using a meta-analysis of proportions performed in R software.

Results

Fifty-four studies, including more than 7,000 patients, were analyzed. The pooled recurrence rate was 8.4%, with arthroscopic excision showing a lower rate (7.8%) than open excision (9.1%), although the difference was not statistically significant. Subgroup analyses favored arthroscopy for volar and primary ganglia, while the results for dorsal ganglia were variable. Overall complication rates were low, with reoperation (3.9%), hematoma (0.7%), and nerve injury (3.4%) being comparable between the techniques. Abnormal scarring occurred more frequently after an open excision. Pain improvement and patient satisfaction were consistently high in both groups, with a modest advantage for arthroscopy.

Conclusion

Open and arthroscopic excisions are safe and effective for treating wrist ganglion cysts. Arthroscopy was associated with lower overall recurrence and reduced recurrence in the volar and primary ganglia, while complication rates remained low and comparable. In addition, arthroscopy offers advantages in terms of cosmesis, pain improvement, and patient satisfaction. Further high-quality studies with standardized outcomes are warranted to confirm these findings and refine decision-making.

Introduction

Ganglion cysts are the most common benign soft-tissue masses of the hand and wrist, typically presenting as mucin-filled cystic swellings arising from the joint capsules or tendon sheaths. They are most frequently located on the dorsal aspect of the wrist (70%) and less commonly on the volar side (30%) [1]. They may present with pain, limited wrist range of motion, or cosmetic issues. Spontaneous resolution is reported in up to 50% of cases, but persistent or symptomatic cysts require intervention [1].

Globally, the incidence of ganglion cysts is approximately 43 per 100,000 in females and 25 per 100,000 in men [2]. The management of wrist ganglions involves conservative measures, such as observation or aspiration with or without corticosteroid injection or hyaluronidase [3].

Surgical management is a more definitive treatment, typically achieved through open excision, which enables the complete removal of the cyst and its stalk but carries the risk of scarring, joint stiffness, and neurovascular injury [4]. An arthroscopic technique, first described by Osterman and Raphael in 1995, has emerged as a minimally invasive alternative to open excision [5].

Utilizing radiocarpal and midcarpal portals, arthroscopy enables complete visualization of intra-articular pathology while minimizing incision size, thereby improving cosmesis and potentially reducing recovery time [5]. Despite its increasing popularity, the comparative effectiveness of arthroscopic versus open excision in terms of recurrence and complications remains debatable.

Several studies have evaluated the recurrence and complication rates following open and arthroscopic excision of wrist ganglions. Clark et al. and Crawford et al. conducted systematic reviews and meta-analyses focusing on dorsal wrist ganglion, encompassing over 1,600 and 900 patients, respectively. Their pooled data demonstrated lower recurrence rates for arthroscopic excision (9.4% and 9%) than for open excision (11.2% and up to 20%), alongside reduced complication rates (7.5%–4% vs. 10.7%–6%) [6, 7]. Arthroscopic surgery is also associated with significantly higher patient satisfaction (89.2% vs. 85.6%) and slightly greater postoperative pain relief [6]. Focusing on volar wrist ganglion, a systematic review of 232 arthroscopic cases reported a mean recurrence rate of 6.03% and a 6.89% complication rate, mainly related to neurovascular structures, such as the radial artery and median nerve [8]. This study emphasizes the increased technical complexity of arthroscopic management of volar ganglia.

Broadening the scope to include aspiration, Head et al. analyzed 2,239 ganglion cases and reported recurrence rates of 59% for aspiration, 21% for open excision, and 6% for arthroscopic excision. Aspiration had the lowest complication rate (3%) [2]. Finally, Horvath et al. reviewed 11 studies, including both randomized controlled trials (RCTs) and observational data. They found highly variable recurrence rates across all modalities, ranging from 7% to 72% for aspiration, 6% to 41% for open excision, and 0% to 16% for arthroscopy [9]. Their findings reaffirmed the advantages of surgical excision while emphasizing the need for standardized techniques and outcome reporting. Together, these reviews suggest that arthroscopic excision offers superior recurrence and complication profiles, with added benefits in patient-centered outcomes, although anatomical location and surgical expertise remain important determinants of success.

Although several systematic reviews and meta-analyses have evaluated the outcomes of arthroscopic versus open excision of wrist ganglion cysts, most are outdated, limited in scope, or focused exclusively on dorsal ganglia. Since their publication, new comparative studies and larger series have emerged that could significantly influence the pooled estimates of recurrence and complication rates. A comprehensive meta-analysis is warranted to clarify the comparative efficacy and inform surgical decision-making.

This systematic review and meta-analysis aimed to explore and compare the recurrence and complication rates following arthroscopic versus open excision of wrist ganglion cysts.

Methods

This study was conducted based on a pre-specified protocol registered in PROSPERO (CRD420251128871). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed in this study.

Eligibility criteria

All RCTs, cohort studies, case-control studies, and case series with at least 10 patients that assessed the efficacy or safety of arthroscopic or open excision for the treatment of wrist ganglion cysts were eligible for inclusion. Included studies were required to report at least one of the following outcomes: recurrence rates (primary outcome) or complication rates (secondary outcome), with a minimum follow-up period of three months. Only full-text articles in English that involved human subjects were considered. The exclusion criteria included review articles, editorials, conference abstracts, cadaveric studies, case reports, and studies that did not focus on open or arthroscopic surgical techniques for wrist ganglion excision.

Search strategy

A comprehensive electronic literature search was conducted in PubMed, Embase, MEDLINE, and Cochrane Central Register of Controlled Trials (CENTRAL). The search was performed using the Ovid platform, with the most recent search conducted on June 27, 2025. The following search terms and Boolean operators were used: (“ganglion” OR “wrist ganglion” OR “ganglion cyst”) AND (“excision” OR “open excision” OR “open surgery” OR “arthroscopic” OR “endoscopic”).

Study selection and data extraction

Title and abstract screening, full-text assessment, and data extraction were conducted independently by two reviewers each. Any discrepancies during the selection or extraction process were resolved through discussion or by involving a third reviewer. The extracted data included study characteristics, patient demographics, cyst features, surgical techniques, follow-up duration, recurrence rates, and postoperative complications.

Statistical analysis

A meta-analysis of proportions was performed using the metaprop function from the meta package in R Software (version 8.2-0). A random-effects model was used.

Two estimation methods were used: the inverse variance method (method = "Inverse") was employed to allow visualization of study weights. In contrast, the generalized linear mixed model (GLMM) was used as an alternative primary method in studies with very low event rates, allowing valid estimation without continuity corrections.

Heterogeneity across studies was quantified using the I^2 statistic, with I^2 values > 80% considered indicative of substantial heterogeneity. To reduce heterogeneity and assess robustness, a sensitivity analysis was conducted by excluding studies with extreme proportions and wide confidence intervals (CIs). These studies contributed minimal weight but disproportionately inflated the heterogeneity estimates.

Forest plots were generated to display the individual study proportions, 95% confidence intervals, and relative weights. Subgroup analysis was conducted based on surgical technique (arthroscopic versus open), and statistical differences between the subgroups were assessed using chi-squared tests. Statistical significance was set at $p < 0.05$.

Results

Search results and study selection

A total of 11,208 records were identified in the databases. After removing 3,574 duplicates, 7,634 records were screened and 7,543 were excluded. Of the 91 full-text articles reviewed, 33 were excluded for reasons such as

language, access, and irrelevance. Sixty studies met the inclusion criteria: 58 from databases and 2 from reference and citation screening of the included studies [10–69] (Fig. 1).

Studies characteristics

The included 60 studies involved 7,173 patients and 7,233 ganglia or hands. The surgery type was reported as open in 32 studies, arthroscopic in 21 studies, and both open and arthroscopic in seven studies. The study designs included 27 retrospective cohorts, 13 case series, nine RCTs, seven prospective cohorts, two case-control studies, and one cross-sectional study. The included studies were conducted across 20 countries, with the highest number from the United States of America (USA) (14 studies). Sex distribution was reported in 52 studies (2,214 men, 3,959 women), while laterality was explicitly reported in 13 studies, with 554 right-hand and 547 left-hand cases (Table 1).

Table 1
Summary of included studies' baseline characteristics.

Study number	First author, publication year	Country	Study design	Surgery type	Patients number/ male/female	Ganglions or hands number/right hand/left hand
1	H Gündeş et al., 2000	Turkey	Retrospective Cohort	Open	40/12/28	40/26/14
2	Sebastian Kuliński et al., 2019	Poland	Retrospective Cohort	Open	394/105/289	395/178/216
3	Jonathan Lans et al., 2023	USA	Retrospective Cohort	Open and Arthroscopic	1076/331/745	1080/NR/NR
4	Hyun Il Lee et al., 2015	Korea	Retrospective Case Control	Open and Arthroscopic	45/18/27	45/26/19
5	Noppachart Limpaphayom et al., 2004	Thailand	RCT	Open	11/2/9	11/6/5
6	R. Luchetti et al., 2000	USA	Retrospective Cohort	Arthroscopic	34/10/24	34/15/19
7	M. Jagers Op Akkerhuis et al., 2002	Netherlands	RCT	Open	38/NR/NR	38/ NR/NR
8	Marco Rizzo et al., 2004	USA	Retrospective Cohort	Arthroscopic	41/17/24	41/ NR/NR
9	L. Rocchi et al., 2006	Italy	Case Series	Arthroscopic	47/13/34	47/ NR/NR
10	Pak-cheong HO et al., 2006	China	Retrospective Cohort	Open and Arthroscopic	21/11/10	21/NR/NR
11	Gürpınar T et al., 2020	Turkey	RCT	Open and Arthroscopic	40/15/25	40/16/24
12	Gregory et al., 2012	USA	Case Series	Open	18/NR/NR	18/NR/NR
13	Abehsera et al., 2018	France	Retrospective Cohort	Arthroscopic	30/5/25	30/17/13
14	Ahsan et al., 2014	USA	Case Series	Arthroscopic	27/7/20	27/NR/NR
15	Shah et al., 2019	India	Prospective Cohort	Open	18/NR/NR	86/NR/NR
16	Al-Qattan et al., 2024	Saudi Arabia	Retrospective Cohort	Open	40/13/27	40/NR/NR
17	Bilal et al., 2022	Pakistan	Cross-sectional	Open	52/19/33	52/34/18

USA: United States of America; UK: United Kingdom; RCT: Randomized Controlled Trial; NR: Not Reported; SD: Standard Deviation; IQR: Interquartile Range.

Study number	First author, publication year	Country	Study design	Surgery type	Patients number/ male/female	Ganglions or hands number/right hand/left hand
18	Balazs et al., 2015	USA	Retrospective Cohort	Open	125/85/40	125/NR/NR
19	Ribau et al., 2022	Portugal	Retrospective Cohort	Arthroscopic	16/4/12	16/8/8
20	Rochlin et al., 2022	USA	Retrospective Cohort	Arthroscopic	2420/969/1451	2420/NR/NR
21	Reddy et al., 2024	India	RCT	Open	50/17/33	50/NR/NR
22	Yamamoto et al., 2018	Japan	Prospective Cohort	Arthroscopic	42/15/27	42/NR/NR
23	Ricardo Kaempf de Oliveira et al., 2019	Brazil	Case Series	Arthroscopic	21/5/16	21/16/5
24	S. Nishikawa et al., 2001	Japan	Case Series	Arthroscopic	37/13/24	37/NR/NR
25	Alvin Chao-Yu Chen et al., 2010	Taiwan	Case Series	Arthroscopic	15/1/14	15/NR/NR
26	C. Mathoulin et al., 2004	France	Case Series	Arthroscopic	128/26/102	128/NR/NR
27	Jack G. Graham et al., 2021	USA	Case Series	Open	20/8/12	20/11/9
28	Maaz-Ul-Hassan et al., 2017	Pakistan	RCT	Open	50/22/28	50/32/18
29	de Villeneuve Bargemon et al., 2022	France	Retrospective Cohort	Arthroscopic	81/NR/NR	81/NR/NR
30	Michiro Yamamoto et al., 2012	Japan	Case series	Arthroscopic	22/NR/NR	22/NR/NR
31	Chung et al., 2015	Singapore	Retrospective Cohort	Arthroscopic	29/12/17	29/NR/NR
32	Cluts et al., 2020	USA	Retrospective Cohort	Open	628/NR/NR	628/NR/NR
33	Craik et al., 2012	UK	Retrospective Cohort	Open	48/NR/NR	48/NR/NR
34	Gopalakrishnan et al., 2025	India	RCT	Open	40/NR/NR	40/NR/NR

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Study number	First author, publication year	Country	Study design	Surgery type	Patients number/ male/female	Ganglions or hands number/right hand/left hand
35	Fernandes et al., 2017	Brazil	Retrospective Cohort	Arthroscopic	34/9/25	34/18/16
36	Hajer et al., 2005	Netherlands	RCT	Open	12/NR/NR	12/NR/NR
37	Rocchi et al., 2008	UK	RCT	Open and Arthroscopic	50/16/34	50/NR/NR
38	Gallego et al., 2010	France	Case Series	Arthroscopic	114/27/87	114/60/54
39	Saremi et al., 2022	Iran	Retrospective Cohort	Arthroscopic	20/6/14	20/17/3
40	Shih et al., 2002	Taiwan	Retrospective Cohort	Arthroscopic	32/20/12	32/NR/NR
41	DesRaj Clark et al., 2022	USA	Prospective Cohort	Open	18 /12/6	18/NR/NR
42	I. Langner et al., 2012	Germany	Prospective Cohort	Arthroscopic	46/11/35	46/NR/NR
43	J. Dias et al., 2003	UK	Prospective Cohort	Open	79/NR/NR	79/NR/NR
44	Ricardo Kaempf O et al., 2023	Brazil	Case Series	Arthroscopic	16/NR/NR	16/NR/NR
45	Lana Kang et al., 2008	USA	RCT	Open and Arthroscopic	72/24/48	72/27/35
46	Ho Jung Kang et al., 2013	South Korea	Case Series	Arthroscopic	41/13/28	41/NR/NR
47	Katerina Kasapinova et al., 2023	North Macedonia	Prospective Cohort	Arthroscopic	48/12/36	48/22/26
48	Parwez Sajad Khan et al., 2011	India	RCT	Open	18/3/15	18/10/8
49	Jong Pil Kim et al., 2013	South Korea	Case Series	Arthroscopic	111/57/54	115/NR/NR
50	Matthew W. Konigsberg et al., 2021	USA	Retrospective Cohort	Open and Arthroscopic	172/59/113	172/NR/NR
51	Nicola et al., 2016	Germany	Retrospective Cohort	Arthroscopic	40/14/26	40/NR/NR
52	N.R. Clay et al., 1988	UK	Retrospective Cohort	Open	61/19/42	62/NR/NR

USA: United States of America; UK: United Kingdom; RCT: Randomized Controlled Trial; NR: Not Reported; SD: Standard Deviation; IQR: Interquartile Range.

Study number	First author, publication year	Country	Study design	Surgery type	Patients number/ male/female	Ganglions or hands number/right hand/left hand
53	Scott et al., 2009	USA	Prospective Cohort	Arthroscopic	55/22/33	55/NR/NR
54	J.J. dias et al., 2007	UK	Prospective Cohort	Open	123/43/80	103/NR/NR
55	Philip et al., 2021	USA	Retrospective Cohort	Arthroscopic	53/9/44	53/NR/NR
56	Bo et al., 2022	China	Retrospective Cohort	Arthroscopic	12/6/6	12/NR/NR
57	J.J.Hwang et al., 1999	USA	Retrospective Cohort	Open	18/1/17	19/10/9
58	Jin et al., 2016	South Korea	Retrospective Cohort	Open	52/25/27	52/NR/NR
59	Nazmi et al., 2020	Turkey	Retrospective Clinical Trial	Open	32/13/19	33/5/28
60	Ali et al., 2025	Iraq	Retrospective Cohort	Open	100/38/62	100/NR/NR
Total	-	-	-	-	7173/2214/3959	7233/554/547

USA: United States of America; UK: United Kingdom; RCT: Randomized Controlled Trial; NR: Not Reported; SD: Standard Deviation; IQR: Interquartile Range.

Across the 60 included studies, the mean patient age was 34.5 years (range, 9–84 years). Presenting symptoms were variably reported but most commonly included pain, cosmetic concerns, swelling, weakness, decreased range of motion (ROM), and paresthesia. In total, 4,292 ganglia had documented anatomical site data, with 3,133 (73%) located dorsally and 1,159 (27%) located volarly. Regarding recurrence status, 4,450 cases were classified: 4,111 (92.3%) were primary ganglia and 339 (7.6%) were recurrent. The mode of diagnosis varied among the patients. Clinical evaluation was the most common method, either alone or in combination with imaging. Ultrasound (US) was used in 17 studies and magnetic resonance imaging (MRI) in 10 (Table 2).

Table 2
Summary of patient clinical characteristics and diagnosis modality.

Study number	Age	Presenting symptoms	Site	Primary or recurrent	Mode of diagnosis
1	Mean: 30.2 (range: 16.0–60.0)	NR	Dorsal: 24 and volar: 16	Primary: 40	NR
2	Mean: 39.2 (SD: 16.2)	Pain, weakness, and/or decreased ROM	Dorsal: 286 and volar: 109	NR	Clinical, US, and/or MRI
3	Mean: 41.0 (SD: 15.0)	Pain and/or cosmesis	Dorsal: 633 and volar: 399	NR	NR
4	Mean: 34.5 (range: 18.0–60.0)	Pain	Dorsal: 45	Primary: 45	Clinical, US, and/or MRI
5	Mean: 29.91 (SD: 9.8)	Pain, weakness, and/or anxiety	Dorsal: 11	Primary: 11	Clinical
6	Mean: 30.0 (SD: 10.5)	Pain, weakness, and/or decreased ROM	Dorsal: 34	Primary: 30 and recurrent: 4	Clinical
7	NR	NR	Dorsal: 25 and volar: 13	Primary: 38	Clinical
8	Mean: 29.8 (range: 11.0–56.0)	Pain, swelling, and/or decreased ROM	Dorsal: 41	Primary: 41	Clinical and/or US
9	Mean: 32.0 (range 16.0–61.0)	Pain and/or weakness	Dorsal: 30 and volar: 17	Primary: 40 and recurrent: 7	US and/or MRI
10	Median: 48.6 (IQR: 25.0–69.0)	NR	Volar: 21	Primary: 21	Clinical
11	Mean: 26.4 (SD: 5.3)	NR	Dorsal: 40	Primary: 40	NR
12	NR	Pain and/or cosmesis	Volar: 18	NR	US and/or MRI
13	Mean: 41.0	Pain and/or weakness	Dorsal: 17 and volar: 13	Primary: 29 and recurrent: 1	Clinical
14	Mean 33.0 (range 17.0–63.0)	NR	Dorsal: 27	NR	NR
15	Mean: 24.8 (range 16.0–48.0)	Pain and/or swelling	Dorsal: 18	NR	Clinical and/or US
16	Mean: 28.0	Pain and/or swelling	Dorsal: 40	Primary: 40	Clinical
17	Mean: 24.4 (SD: 6.6)	Pain, weakness, and/or cosmesis	Dorsal: 52	Primary: 52	Clinical

NR: Not Reported; ROM: Range of Motion; MRI: Magnetic Resonance Imaging; US: Ultrasound; IQR: Interquartile Range; SD: Standard Deviation.

Study number	Age	Presenting symptoms	Site	Primary or recurrent	Mode of diagnosis
18	Mean: 31.0 (range 18.0–51.0)	Pain	Dorsal: 125	Primary: 109 and recurrent: 16	Clinical
19	Mean: 33.3 (SD: 12.7)	Pain, paresthesia, cosmesis, and/or decreased ROM	NR	Primary: 14 and recurrent: 2	Clinical, US, and/or MRI
20	Mean: 40.5 (SD: 14.9)	Pain, swelling, and/or decreased ROM	NR	Primary: 2420	Clinical
21	Range: 12.0–58.0	Pain	Dorsal: 31 and volar: 19	Primary: 50	Clinical
22	Mean: 37.5 (SD: 14.1)	Pain, weakness, limited ROM, and/or cosmesis	NR	NR	Clinical
23	Mean: 43.6 (range 18.0–74.0)	Pain, cosmesis, and/or decreased ROM	Volar: 21	Primary: 21	Clinical, US, and/or MRI
24	Mean: 40 (range 14.0–84.0)	Pain and/or cosmesis	Dorsal: 37	NR	Clinical and/or MRI
25	Mean: 35.7 (SD: 15.0)	Pain, swelling, and/or decreased ROM	Dorsal: 12 and volar: 3	Primary: 11 and recurrent: 4	Clinical and/or Xray
26	Mean: 41.5 (range: 15.0–76.0)	Weakness and/or cosmesis	Dorsal: 96 and volar: 32	Recurrent: 128	Clinical and/or MRI
27	Mean: 46.2 (15.0–76.0)	Pain and/or decreased ROM	Dorsal: 8 and volar: 12	Recurrent: 20	Clinical
28	Mean: 48.5 (SD: 5.1)	Swelling and/or cosmesis	NR	Primary: 50	Clinical
29	NR	Pain and/or decreased ROM	Dorsal: 81	NR	Clinical and/or MRI
30	NR	Pain and/or cosmesis	Dorsal: 17 and volar: 5	NR	Clinical and/or MRI
31	Mean: 38.0 (range: 22.0–56.0)	Pain	Dorsal: 26 and volar: 3	Primary: 25 and recurrent: 4	Clinical and/or US
32	NR	NR	Dorsal: 341 and volar: 286	NR	NR
33	Mean: 39.0 (range: 14.0 – 71.0)	Pain, paresthesia, cosmesis, and/or decreased ROM	Dorsal: 29 and volar: 16	NR	NR
34	NR	Swelling	NR	NR	NR
35	Mean: 29.7 (range: 11.0–53.0)	NR	Dorsal: 34	Primary: 26 and recurrent: 8	Clinical and/or US

NR: Not Reported; ROM: Range of Motion; MRI: Magnetic Resonance Imaging; US: Ultrasound; IQR: Interquartile Range; SD: Standard Deviation.

Study number	Age	Presenting symptoms	Site	Primary or recurrent	Mode of diagnosis
36	NR	NR	NR	NR	NR
37	Mean: 37.0 (range 16.0–64.0)	Pain	Volar: 50	Primary: 48 and recurrent: 12	US
38	Mean: 33.1 (range: 12.0–63.0)	Pain and/or cosmesis	NR	Primary: 113 and recurrent: 1	NR
39	NR	Pain and/or cosmesis	NR	Primary: 19 and recurrent: 1	NR
40	Mean: 23.7 (range: 21.0 – 35.0)	Pain and/or cosmesis	NR	NR	NR
41	Mean: 31.4 (SD: 7.3)	Pain and/or decreased ROM	Dorsal: 18	Primary: 18	Clinical
42	Mean: 36.0 (SD :11.0)	Pain and/or decreased ROM	Dorsal: 46	Primary: 28 and recurrent :18	Clinical and/or MRI
43	Mean 45.0 (SD: 17.6)	Pain, weakness, and/or decreased ROM	Volar: 79	NR	Clinical
44	NR	Pain and/or cosmesis	Dorsal: 9 and Volar: 7	NR	Clinical and/or MRI
45	Mean: 35 (range: 10.0–74.0)	Pain, weakness, and/or decreased ROM	Dorsal: 72	Primary: 72	Clinical
46	Mean: 33.7	Pain and/or decreased ROM	NR	Primary: 41	Clinical and/or Xray
47	Mean: 36.2 (range: 16.0–59.0)	Pain, cosmesis, and/or decreased ROM	NR	Primary: 40 and recurrent: 8	Clinical and/or MRI
48	Mean: 31.0 (range: 17.0–45.0)	Pain, weakness, and/or cosmesis	Dorsal: 18	Primary: 18	Clinical
49	Mean: 34.0 (SD: 14.7)	Pain	Dorsal: 111	Primary: 95 and recurrent: 16	US and/or MRI
50	Mean: 37.8 (range: 9.0–76.0)	Pain, weakness, and/or decreased ROM	Dorsal: 172	Primary: 172	Clinical and/or MRI
51	Mean: 29.3 (range: 12.0–55,0)	Pain	Dorsal: 40	Primary: 36 and recurrent: 4	Clinical and/or MRI
52	Mean: 32.0	Pain	Dorsal: 62	Primary: 55 and recurrent: 7	Clinical

NR: Not Reported; ROM: Range of Motion; MRI: Magnetic Resonance Imaging; US: Ultrasound; IQR: Interquartile Range; SD: Standard Deviation.

Study number	Age	Presenting symptoms	Site	Primary or recurrent	Mode of diagnosis
53	Range: 15.0–52.0	Pain and/or cosmesis	Dorsal: 55	Primary: 45 and recurrent: 10	Clinical
54	Mean: 34.9	Pain, weakness, and/or decreased ROM	Dorsal: 123	Primary: 83 and recurrent: 40	Clinical
55	Mean: 32.0	Pain and/or decreased ROM	Dorsal: 33 and volar: 20	Primary: 27 and recurrent: 26	Clinical, US, and/or MRI
56	Mean: 30.7	Pain and/or weakness	Dorsal: 12	NR	US and/or MRI
57	Mean: 28.4	Pain	Dorsal: 18	Primary: 17 and recurrent: 1	Clinical and/or US
58	Mean: 36.8	Pain, weakness, and/or decreased ROM	Dorsal: 52	NR	Xray and/or US
59	Mean: 38.6 (SD: 13.0)	Pain and/or decreased ROM	Dorsal: 32	Primary: 31 and recurrent: 1	US
60	NR	Pain and/or cosmesis	Dorsal: 100	NR	Clinical
Total	Mean: 34.5	-	Dorsal: 3133 and volar: 1159	Primary: 4111 and recurrent: 339	-

NR: Not Reported; ROM: Range of Motion; MRI: Magnetic Resonance Imaging; US: Ultrasound; IQR: Interquartile Range; SD: Standard Deviation.

The type of anesthesia was reported in 46 of the 60 studies. Nerve block was the most common technique (used in 22 studies). Fourteen studies did not specify the anesthesia used. Intraoperative tourniquets were used in 46 studies, with a cumulative total of 5,781 patients. The follow-up duration was reported in all studies, with a mean follow-up of 25.7 months (range: 3–135 months). Recurrence was defined in 35 studies. Of these, 31 studies relied on clinical assessment alone. The remaining 25 studies did not clearly define the criteria used to assess recurrences (Table 3).

Table 3
Summary of surgical characteristics, follow-up duration, and definition of recurrence.

Study number	Anesthesia type	Use of intraoperative tourniquet	Follow-up duration in months	Recurrence definition
1	NR	0	Mean: 27.0 (range: 6.0–27.0)	NR
2	NR	1080	Mean: 38.0 (range: 24.0 – 118.0)	Clinical
3	NR	0	Median: 57.6 (IQR: 19.2–112.8)	Clinical
4	Nerve block	11	Mean: 32.0 (range: 18.0 – 49.0)	Clinical and/or US
5	Local	34	Mean: 6.0	Clinical
6	Nerve block or general	38	Mean: 13.5 (SD: 12.4)	Clinical
7	Local	41	Mean: 12.0	NR
8	NR	47	Mean: 47.8 (range: 28.0 – 97.0)	Clinical
9	Nerve block	395	Mean: 5.0 (range 3.0 – 26.0)	NR
10	Local	21	Median: 56.0 (IQR: 9.0–101.0)	NR
11	Local or general	0	Mean: 18.0	NR
12	NR	0	Mean: 11.0	Clinical
13	Nerve block	30	Mean: 55.2	NR
14	NR	0	Mean: 25.0 (range 12.0–42.0)	Clinical
15	Local	0	Mean: 12.0	Clinical
16	Local	0	Mean 23.0	Clinical
17	Local	52	Mean: 6.0	Clinical
18	NR	125	Mean: 45.0 (range 12.0–102.0)	NR
19	NR	16	Mean: 30.0 (range 6.0–62.0)	Clinical
20	NR	2420	Mean: 15.0	Clinical
21	Local	50	Mean: 6.0	Clinical
22	NR	0	Mean: 20.5 (SD: 5.2)	Clinical
23	Nerve block	21	Mean: 10.9 (range: 6.0 – 36.0)	Clinical

NR: Not Reported; MRI: Magnetic Resonance Imaging; US: Ultrasound; IQR: Interquartile Range; SD: Standard Deviation.

Study number	Anesthesia type	Use of intraoperative tourniquet	Follow-up duration in months	Recurrence definition
24	Nerve block or general	37	Mean: 20 (range 1.0–42.0)	Clinical
25	Nerve block or general	15	Mean :15.3 (range 12.0–26.0)	Clinical
26	Nerve block	128	Mean: 30.0	Clinical
27	NR	0	Mean: 11.0	Clinical
28	NR	50	Mean: 3.0	Clinical
29	Nerve block	81	Mean: 31.6	Clinical
30	Nerve block	22	Mean: 21.0	Clinical
31	NR	0	Range: 6.0–32.0	NR
32	NR	0	Mean: 60.0	NR
33	Nerve block or general	48	Mean: 39.0 (range: 16.0–71.0)	NR
34	NR	0	Mean: 12.0	NR
35	Nerve block or general	34	Mean: 81.0 (range: 48.0–135.0)	NR
36	NR	0	Mean: 6.0	NR
37	Nerve block	50	Mean: 24.0	NR
38	Nerve block or general	114	Mean: 42.3 (range: 24.0–74.0)	NR
39	General	20	Mean: 36.0	NR
40	Nerve block	0	Range: 15.0–37.0	NR
41	NR	0	Mean: 6.0	Clinical
42	Nerve block or general	46	Mean: 12.0	Clinical
43	NR	0	Mean: 63.0 (IQR: 55.0–87.0)	Clinical
44	Nerve block	16	Mean: 12.0	Clinical
45	Nerve block or general	72	Mean: 12.0	Clinical
46	General	41	Mean: 38.9	Clinical
47	General	48	Mean: 24.0	Clinical
48	Local	0	Mean: 12.0	Clinical

NR: Not Reported; MRI: Magnetic Resonance Imaging; US: Ultrasound; IQR: Interquartile Range; SD: Standard Deviation.

Study number	Anesthesia type	Use of intraoperative tourniquet	Follow-up duration in months	Recurrence definition
49	Nerve block or general	111	Mean: 32.0 (SD: 17.3)	Clinical
50	NR	0	Mean: 3.1	Clinical
51	Nerve block	40	Mean: 28.5	NR
52	General	0	Mean: 28.0	Clinical
53	NR	55	Mean: 24.0	NR
54	Local or general	123	Mean: 70.4	NR
55	Nerve block or general	53	Median 12.0 (IQR: 6.0–23.0)	NR
56	Nerve block	12	Mean: 24.0	Clinical and/or MRI
57	NR	0	Mean: 13.0	NR
58	Nerve block or general	52	Mean: 26.0	NR
59	Nerve block or general	32	Mean: 21.7 (SD: 9.4)	US
60	Nerve block or general	100	Range: 12.0–18.0	NR
Total	-	5781	Mean: 25.7	-

NR: Not Reported; MRI: Magnetic Resonance Imaging; US: Ultrasound; IQR: Interquartile Range; SD: Standard Deviation.

Overall recurrence rates

A total of 54 studies were included in the meta-analysis of recurrence after wrist ganglion excision. The initial pooled recurrence rate across all studies was 10.2% (95% CI: 8.2–12.5%). However, heterogeneity was substantial ($I^2 = 85.9\%$, $p < 0.0001$).

Sensitivity analysis was performed by excluding seven statistical outliers [14, 16, 28, 38, 45, 52, 63]. After removal, 47 studies were included, and the pooled recurrence rate decreased to 8.4% (95% CI: 6.9%–10.2%). The trend persisted, with open excision again demonstrating a higher recurrence rate (9.1%, 95% CI: 7.2% to 11.3%) than arthroscopic excision (7.8%, 95% CI: 5.8% to 10.5%), although the difference was not statistically significant ($p = 0.44$). Heterogeneity improved but remained considerable ($I^2 = 76.6\%$, $p < 0.0001$) (Fig. 2).

Dorsal wrist ganglia recurrence rates

A total of 32 studies reported recurrence following the excision of dorsal wrist ganglion cysts. The pooled recurrence rate was 10.8% (95% CI: 8.4%–13.9%). Heterogeneity was moderate to high ($I^2 = 73.5\%$, $p < 0.0001$).

After the sensitivity analysis, excluding three outlier studies, 29 studies remained in the final model [14, 16, 63]. The pooled recurrence rate slightly decreased to 9.8% (95% CI: 7.7%–12.4%). Open excision was associated with a lower

recurrence rate than arthroscopy (8.1%, 95% CI: 6.6% to 10.1%) versus (11.3%, 95% CI: 7.9% to 16.1%). Although the trend favored open excision, the difference was not statistically significant (p = 0.125). Heterogeneity improved overall (I^2 = 56.5%, p < 0.001) (Fig. 3).

Volar wrist ganglia recurrence rates

In the initial analysis, eight studies were included, which reported recurrence following excision of volar wrist ganglion cysts. The pooled recurrence rate was 17.0% (95% CI: 9.6–28.3%). Heterogeneity was substantial (I^2 = 78.7%, p < 0.0001).

After excluding one statistical outlier, the final analysis included seven studies [14]. The updated pooled recurrence rate dropped to 13.8% (95% CI: 8.1%–22.4%). Recurrence remained lower in the arthroscopic group (9.1%, 95% CI: 4.2% to 18.9%) than in the open group (16.5%, 95% CI: 8.1% to 30.8%), without a statistically significant difference (p = 0.254). Heterogeneity decreased overall (I^2 = 42.8%, p = 0.093) (Fig. 4).

Primary ganglia recurrence rates

In the initial analysis, 17 studies were included, which reported recurrence following the excision of primary ganglion cysts. The pooled recurrence rate was 9.7% (95% CI: 6.6–13.9%). Heterogeneity was substantial (I^2 = 86.8%, p < 0.0001).

After excluding one statistical outlier, the final analysis included 16 studies [29]. The updated pooled recurrence rate increased to 11.9% (95% CI: 9.1%–15.3%). Recurrence remained lower in the arthroscopic group (11.3%, 95% CI: 7.9% to 16.1%) than in the open group (12.4%, 95% CI: 8.5% to 17.6%), without a statistically significant difference (p = 0.739). The heterogeneity decreased overall (I^2 = 25.9%, p = 0.140) (Fig. 5).

Recurrence rates with the use of an intraoperative tourniquet

In the initial analysis, 36 studies were included to evaluate recurrence rates following wrist ganglion excision with the use of an intraoperative tourniquet. The overall pooled recurrence rate was 10.6% (95% CI: 8.4%–13.4%), with substantial heterogeneity (I^2 = 72.3%, p < 0.001).

After excluding three statistical outliers, the final analysis included 33 studies [38, 45, 50]. The overall pooled recurrence rate was 9.9% (95% CI: 8.2%–11.9%). The recurrence rate in the open subgroup was 10.7% (95% CI: 7.6%–14.8%), whereas in the arthroscopic subgroup, the recurrence rate was slightly lower at 9.6% (95% CI: 7.7%–11.9%). No statistically significant difference was observed between the subgroups (p = 0.581). Overall, the heterogeneity decreased (I^2 = 20.5%, p = 0.141) (Fig. 6).

Reoperation rates

A total of 24 studies were included in the meta-analysis that evaluated reoperation rates following wrist ganglion excision. The overall pooled reoperation rate was 3.9% (95% CI: 2.9%–5.2%). In the open subgroup, the pooled reoperation rate was also 4.0% (95% CI: 2.5% to 6.5%), and in the arthroscopic subgroup, the pooled rate was 4.0% (95% CI: 2.8–5.8%). No statistically significant difference was observed between the surgical subgroups (p = 0.989). No heterogeneity was observed among the studies (I^2 = 0.0%, p = 0.726) (Fig. 7).

Conversion rates from attempted arthroscopic to open excision

Six studies reported on conversion from arthroscopic to open excision for wrist ganglion cysts. The pooled conversion rate was 8.4% (95% CI: 4.0%–16.9%). Moderate heterogeneity was observed across the studies (I^2 = 61.4%, p = 0.023) (Fig. 8).

Hematoma rates

Four studies reported postoperative hematoma rates following wrist ganglion excision. The overall pooled hematoma rate was 0.7% (95% CI: 0.2%–2.7%), with low heterogeneity (I^2 = 52.5%, p = 0.097). In the arthroscopic subgroup, the hematoma rate was 0.6% (95% CI: 0.1% to 3.0%), while the open subgroup had a higher reported hematoma rate of 1.6% (95% CI: 0.0% to 8.7%). There was no statistically significant difference in hematoma rates between the arthroscopic and open excision techniques (p = 0.422) (Fig. 9).

Nerve injury rates

Fourteen studies reported postoperative nerve injury rates, including motor or sensory loss. In the initial meta-analysis, the overall pooled rate of nerve injury was 4.6% (95% CI: 2.6%–8.0%), with moderate heterogeneity (I^2 = 67.6, p < 0.001).

A sensitivity analysis was performed, and one outlier was excluded [43]. The updated analysis included 13 studies and yielded a reduced overall nerve injury rate of 3.4% (95% CI: 2.4%–4.8%), and heterogeneity was eliminated (I^2 = 0%, p = 0.876). Subgroup analysis in the sensitivity model demonstrated consistent rates; the open excision had a rate of 3.5% (95% CI: 2.3%–5.1%), and the arthroscopic excision had a rate of 3.3% (95% CI: 1.6%–6.4%). No significant difference was observed between the groups (p = 0.881) (Fig. 10).

Wrist stiffness and decreased range of motion rates

Thirteen studies reported postoperative wrist stiffness or decreased range of motion after ganglion cyst excision. The initial pooled analysis showed an overall complication rate of 7.7% (95% CI: 3.7% to 15.5%), with substantial heterogeneity (I^2 = 86.5%, τ^2 = 1.7722, p < 0.0001).

A sensitivity analysis was performed by excluding two outliers, resulting in a slightly higher overall pooled rate of 9.0% (95% CI: 5.4% to 14.8%) and reduced heterogeneity (I^2 = 75.7%, p < 0.001) [13, 41]. The open excision subgroup showed a lower rate of 8.4% (95% CI: 4.5%–15.0%). The arthroscopic subgroup had a higher rate of 11.0% (95% CI: 3.5% to 29.7%). No significant subgroup differences were identified post-sensitivity (p = 0.666) (Fig. 11).

Abnormal scar formation rates

Eight studies reported abnormal scar formation, including hypertrophic scars or keloids, after wrist ganglion excision. The overall combined rate was 6.9% (95% CI: 5.3% to 8.9%) with low heterogeneity across all studies (I^2 = 17.5%, P = 0.29). The pooled proportion was higher in the open subgroup at 7.2% (95% CI: 5.5–9.5%). In comparison, the arthroscopic subgroup demonstrated a lower pooled rate of 2.4% (95% CI: 0.6%–8.9%). No statistically significant difference was observed between the open and arthroscopic approaches (p = 0.11) (Fig. 12).

Pain improvement rates

Sixteen studies reported the postoperative pain improvement rates. The initial analysis showed a rate of 89.0% (95% CI: 78.0% to 94.8%) with high heterogeneity (I2 = 90.0%, p < 0.001).

A sensitivity analysis was performed by excluding one outlier, yielding 15 studies [33]. The pooled rate was 89.8% (95% CI: 82.4% to 94.3%), with moderate heterogeneity (I^2 = 69.4%, p < 0.001). There was a statistically significant difference in scar formation rates between the arthroscopic and open approaches (p = 0.012), with the arthroscopic subgroup demonstrating higher rates (94.4%, 95% CI: 87.1% to 97.7%) than the open subgroup (80.8%, 95% CI: 69.9% to 88.4%) (Fig. 13).

Patient-reported satisfaction

Sixteen studies reported patient-reported satisfaction following wrist ganglion excision. The overall pooled satisfaction rate was 85.1% (95% CI: 81.7% to 88.0%) with negligible heterogeneity (I^2 = 0%, P = 0.729). In the arthroscopic subgroup, the pooled satisfaction rate was 87.0% (95% CI: 81.3% to 91.1%), whereas in the open surgery subgroup, the pooled satisfaction rate was 84.2% (95% CI: 79.8% to 87.8%). No statistically significant difference was observed in the satisfaction rates between the two surgical approaches (p = 0.394) (Fig. 14).

Discussion

This systematic study and meta-analysis of over 7,000 cases provides the most thorough assessment available of the outcomes following surgical wrist ganglion excision. The analyzed recurrence rate was 8.4%, with arthroscopic excision exhibiting a reduced recurrence rate of 7.8% compared to open excision at 11.3%; however, this disparity did not achieve statistical significance. These results align with those of Fernandes et al., who reported recurrence rates of 0–20% following arthroscopic resection versus 14–42% after open excision, and ofe with Crawford et al., who reportedrecurrence rates of 20% (ranging from 5.6–40.7%) for open excision and 9% for arthroscopic treatments [2, 6, 9].

Recurrence and Subgroup Analysis

Subgroup analyses provided additional insights. The dorsal ganglia had an overall recurrence rate of 9.8%. Although our study indicated that the recurrence rate was higher with arthroscopy (11.3%) than with open excision (8.1%), the difference was not statistically significant. In contrast, Clark et al. reported a significantly lower recurrence rate after arthroscopy (9.4%) than after open excision (11.2%) [6]. Horvath et al. reported a wide range of arthroscopy recurrence rates, indicating variability in surgical technique and patient selection [9]. Taken together, these findings indicate that both methods are viable for the dorsal ganglia, although arthroscopy may provide minor advantages in certain situations.

For volar ganglia, recurrence was higher overall (13.8%), whereas arthroscopy was associated with decreased recurrence (9.1% vs. 16.5% for open excision). These findings are consistent with those of Fernandes et al., who found that volar ganglia had a 13.8% recurrence rate [8]. The lower recurrence in volar ganglia than in dorsal ganglia may be explained by anatomical differences: volar cysts are generally smaller and more accessible, facilitating complete arthroscopic excision, whereas dorsal cysts often arise from the scapholunate joint, where visualization is more limited and stalk removal is more technically demanding [8].

For primary ganglia, recurrence was 11.9%, with outcomes favoring arthroscopic excision over open surgery (11.3% and 12.4%, respectively). Given the limited reporting on primary ganglia in the literature, these findings add valuable evidence to an underexplored subgroup [2, 6–9].

Tourniquet use was evaluated in 33 studies, with a recurrence rate of 9.9%. In line with other studies, arthroscopy was associated with a decreased risk of recurrence; however, no direct correlation between tourniquet use and outcomes

hasbeen identified [2, 7, 8]. This emphasizes the necessity of conducting additional investigations to evaluate intraoperative variables aside from surgical technique selection.

Complications

Overall, the complication rates were minimal, demonstrating the safety of both treatments. According to other systematic reviews, the reoperation rate was 3.9% and was equivalent for both open and arthroscopic excisions (4.0% each) [2, 6–9]. Arthroscopy was converted to open surgery in 8.4% of patients because of technical difficulties and the risk of vascular injury. Similar conversion percentages were reported by Clark et al. and others, highlighting the significance of intraoperative judgment and preoperative counseling when choosing a surgical technique [6].

The overall hematoma rate was 0.7%, slightly higher with open excision (1.6%) than with arthroscopy (0.6%). This discrepancy most likely results from arthroscopic procedures that cause less tissue damage. According to Crawford et al. and Clark et al., nerve damage occurred in 3.4% of patients, with rates for open (3.5%) and arthroscopic (3.3%) procedures being fairly similar [6, 7]. Portal placement-related neuropraxia is a known danger, highlighting the significance of surgical accuracy and anatomical knowledge.

Compared to surgical excision (8.4%), arthroscopy showed a slightly higher rate (11.0%) of postoperative stiffness and decreased range of motion (9.0%). These results are somewhat in line with Clark et al.'s findings, showing that stiffness is a common complication following open excision (48.3%), although they did not mention arthroscopy rates [6]. Fernandes et al., on the other hand, observed no significant stiffness following arthroscopy [8]. Differences in postoperative rehabilitation and outcome definitions are likely the cause of these contradictory results.

Abnormal scar formation occurred in 6.9% of cases, with open excision (7.2%) being more common than arthroscopy (2.4%). Despite the fact that there remains limited information on scar results, this supports the aesthetic benefits of arthroscopy because it involves minimal incisions and less disruption of soft tissue [7, 8].

Patient-centered Outcomes

Patient-centered outcomes strongly favored arthroscopy. Overall, 89.8% of patients experienced pain relief, with arthroscopy being more effective than open surgery (94.4% vs. 80.8%). However, Clark et al. reported lower rates of pain relief (66.7% for open excision and 69.5% for arthroscopy), which may be due to variations in outcome measurement and baseline pain levels [6].

Patient satisfaction was excellent (85.1%) across both methods, with arthroscopy ratings higher (87.0%) than open excision (84.2%). These findings are consistent with those of Clark et al., who reported satisfaction rates of 89.2% and 85.6%, respectively [6]. Its minimally invasive nature, faster recovery, and superior cosmetic results may be the reasons for the higher satisfaction with arthroscopy.

Limitations

This review has some limitations. First, the generalizability of the findings may be limited by significant heterogeneity across studies. Direct comparisons are difficult because of the bias introduced by variations in surgical technique, patient groups, and study design. Second, the accuracy of the pooled estimates was limited by the varied definitions of complications and recurrence. Finally, although arthroscopy continuously showed a tendency toward better results, most comparisons did not approach statistical significance, underscoring the necessity for higher-quality data.

Despite these limitations, this review has several strengths. It synthesized data from over 7,000 cases, making it the largest meta-analysis conducted to date. To address heterogeneity, sensitivity analyses were performed, and

subgroup analyses focused on dorsal, volar, and principal ganglia, as well as tourniquet use, which are frequently under-reported in the literature. These contributions offer a strong basis for future research and clinical assessments.

Conclusion

This systematic review and meta-analysis revealed an overall recurrence rate of 8.4% after wrist ganglion excision, with arthroscopic excision showing a consistent, though not statistically significant, tendency toward decreased recurrence compared with open surgery. While dorsal outcomes varied, arthroscopy also revealed decreased recurrence in the volar and principal ganglia. Although open excision was more likely to result in abnormal scar formation, the complication rates, such as hemorrhage, nerve damage, and reoperation, were insignificant and comparable. Importantly, pain improvement and patient satisfaction consistently favored arthroscopy. Clinically, both open and arthroscopic excisions are safe and effective, but arthroscopy offers advantages in terms of recurrence, cosmesis, and patient-centered outcomes. It may be particularly suitable for volar and primary ganglia and for patients who prioritize cosmetic results. Surgical decisions should also consider the anatomy and the surgeon's expertise. Future high-quality studies with standardized outcome definitions are needed to confirm these trends and optimize the surgical management of wrist ganglion cysts.

Declarations

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The authors declare that they have no conflicts of interest.

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Author Contribution

1. Abdulaziz M. Alghamdi: Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration2. Ali M. Alkhathami: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization3. Halah Alhwsawi: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization4. Jullanar Saleh Alkhunein: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization5. Yazeed A. Almojel: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization6. Khaled Majed Qanash: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization7. Rayan H. Abuhadi: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization8. Saleh Ghalib Alqadi: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization9. Yousef A Alharbi: Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization10. Ehab Talal Barnawi: Investigation, Data

Curation, Writing - Original Draft, Writing - Review & Editing, Visualization11. Turki Alhassan: Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision

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Data Availability

The Ungdata surveys that support the findings of this study are available upon reasonable request.

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Figures

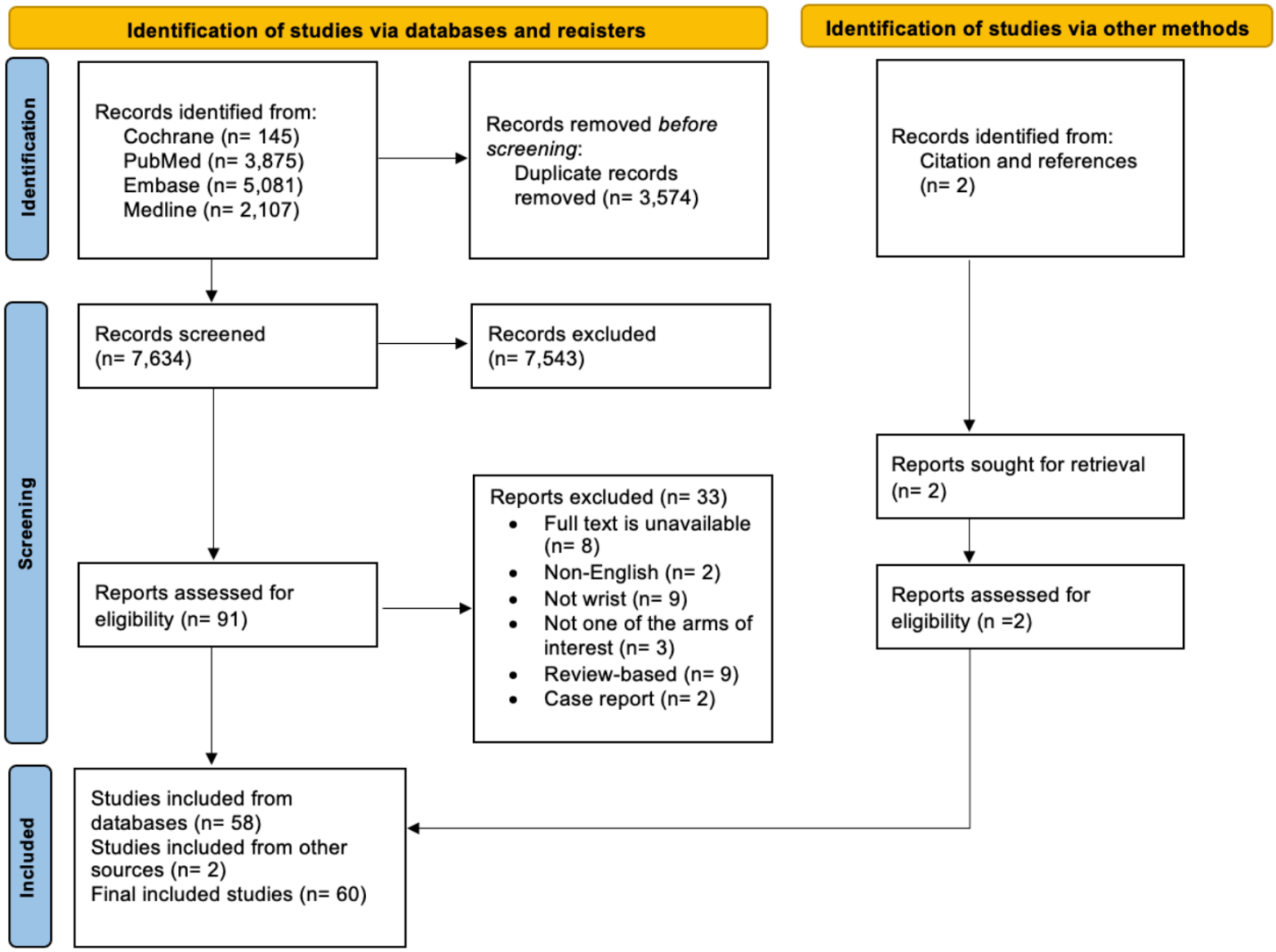


Figure 1

PRISMA chart.

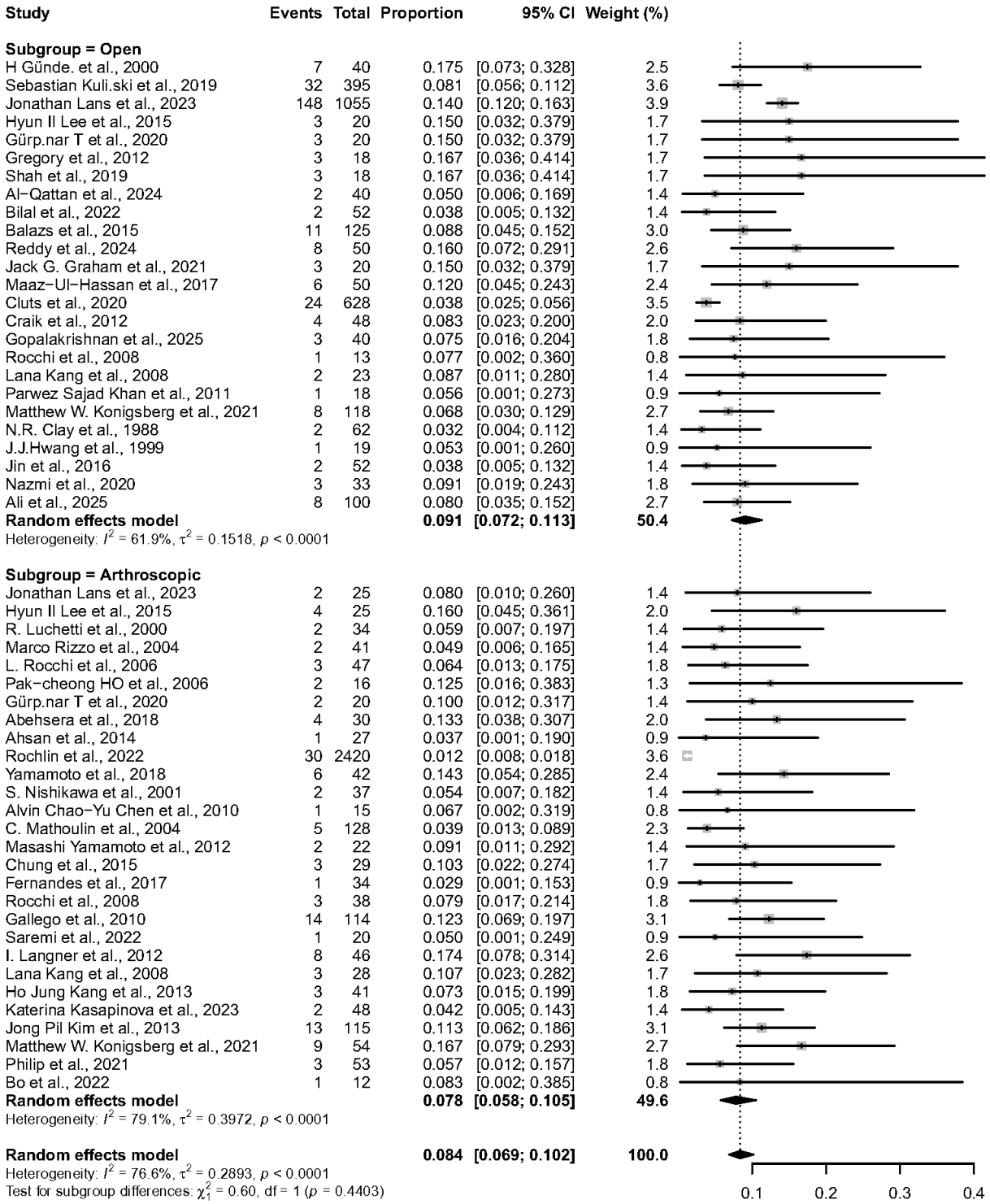


Figure 2

Meta-analysis of overall recurrence rates comparing arthroscopic excision versus open excision of wrist ganglion cysts.

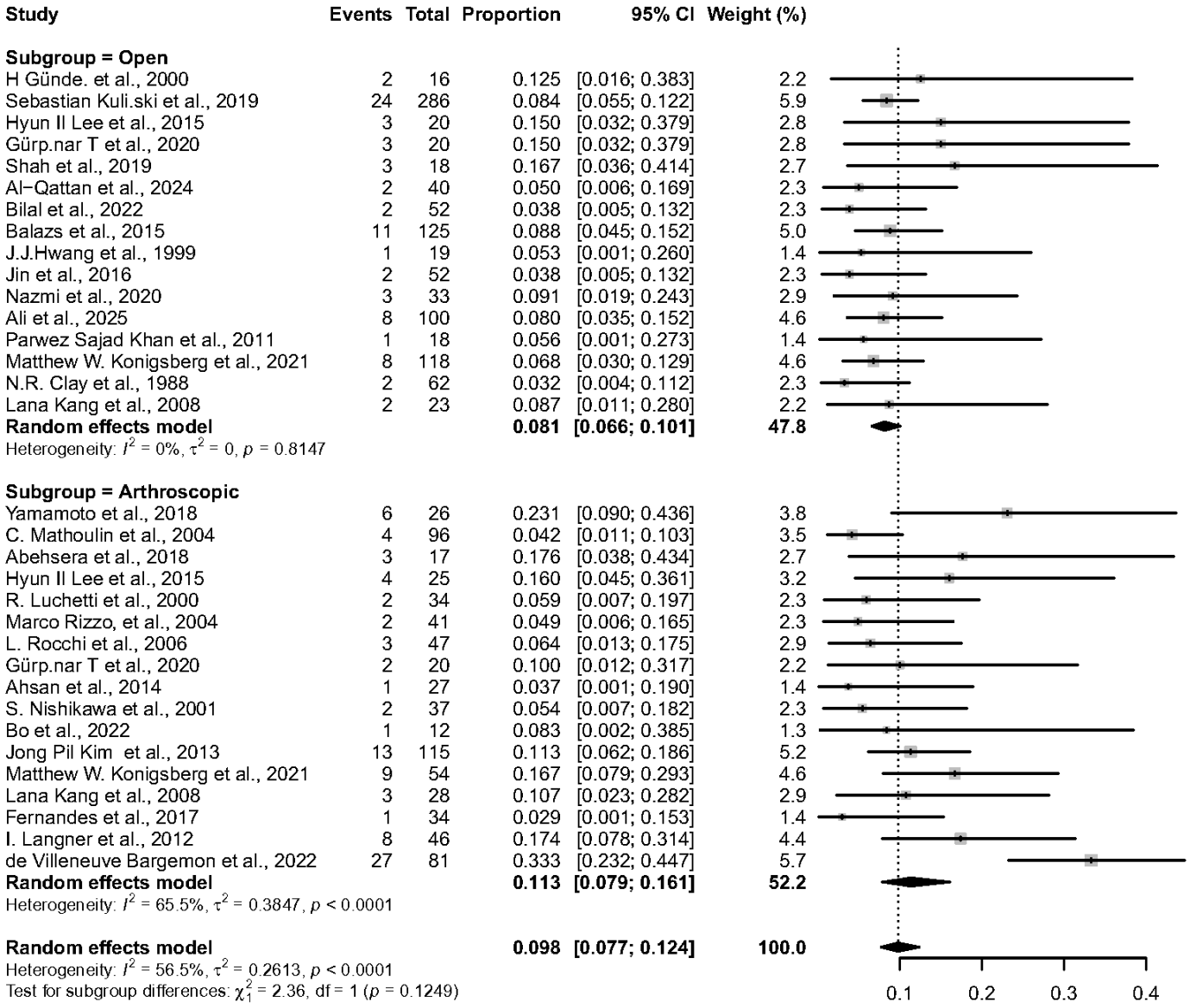


Figure 3

Meta-analysis of recurrence rates in dorsal wrist ganglion cysts comparing arthroscopic excision versus open excision.

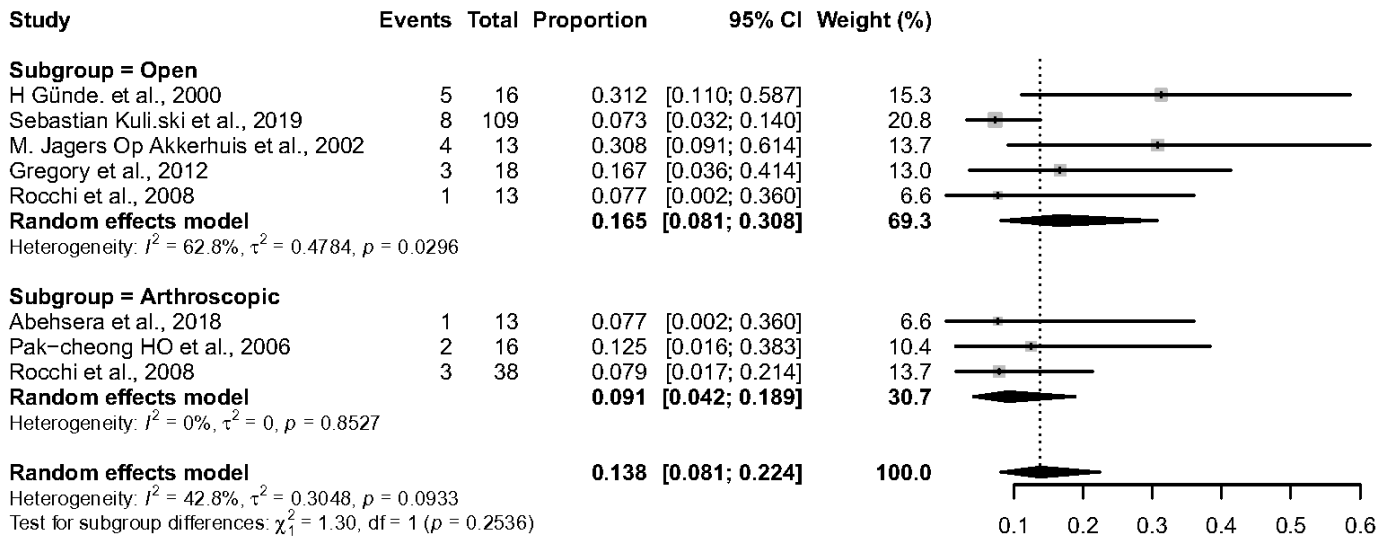


Figure 4

Meta-analysis of recurrence rates in volar wrist ganglion cysts comparing arthroscopic excision versus open excision.

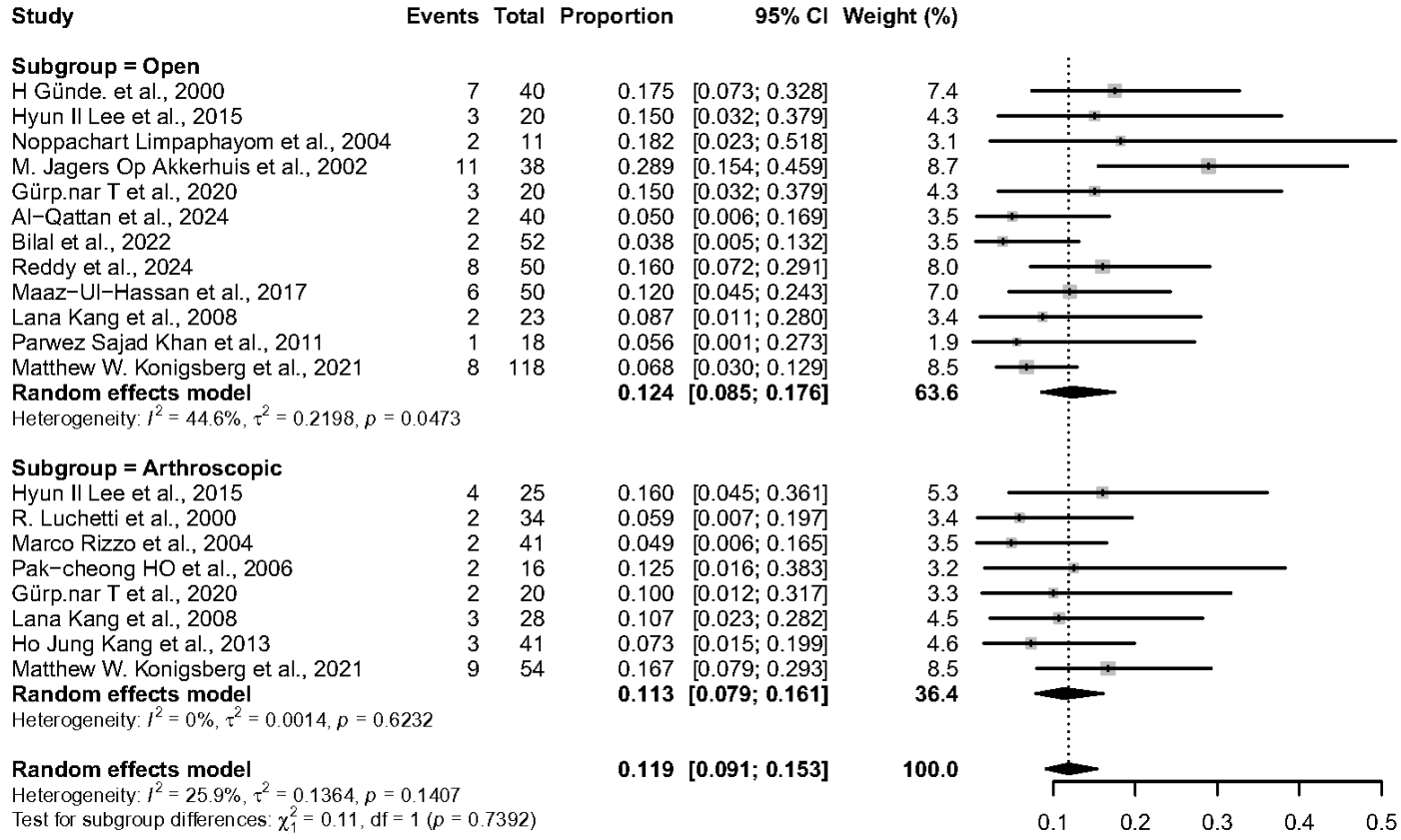


Figure 5

Meta-analysis of recurrence rates in primary wrist ganglion cysts comparing arthroscopic excision versus open excision.

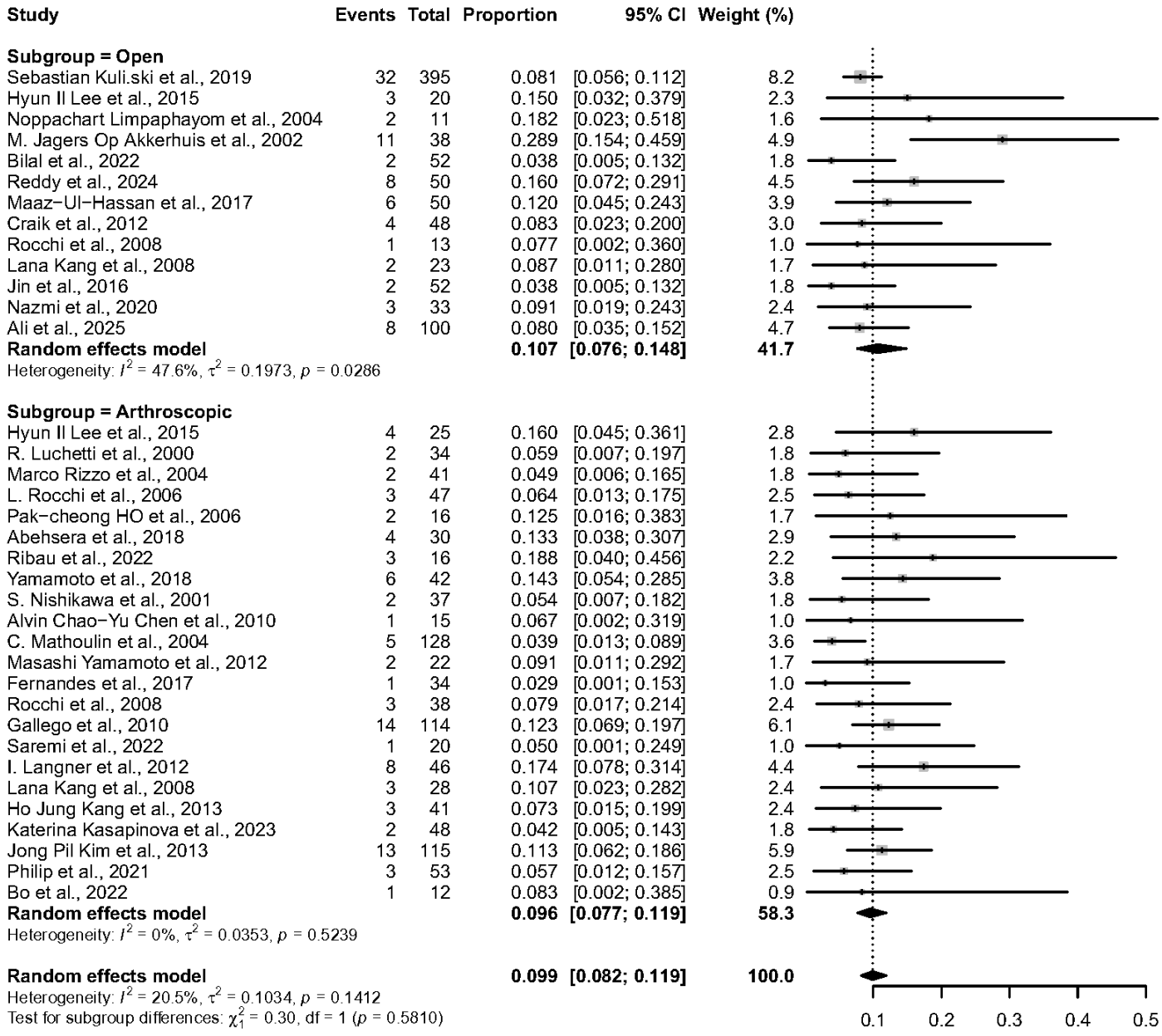


Figure 6

Meta-analysis of recurrence rates with intraoperative tourniquet use comparing arthroscopic excision versus open excision.

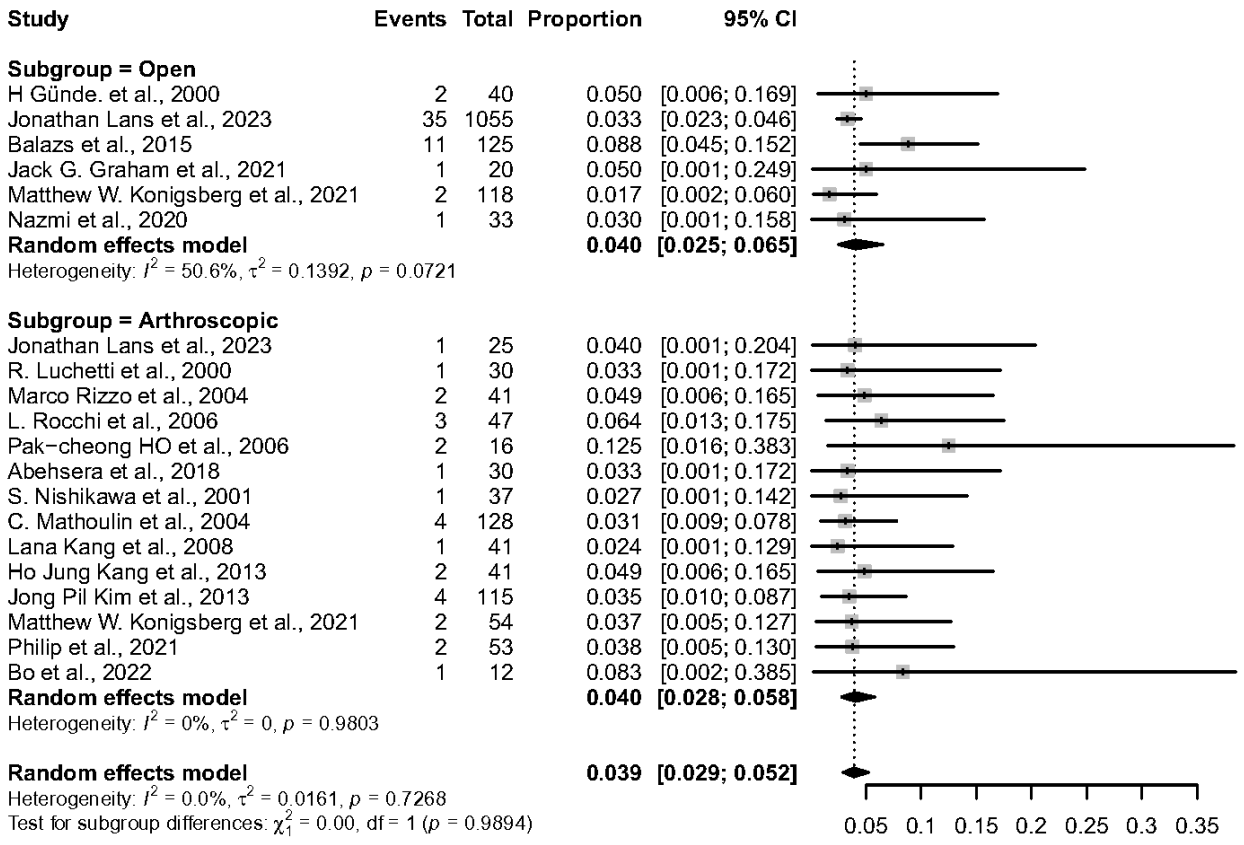


Figure 7

Meta-analysis of reoperation rates comparing arthroscopic excision versus open excision of wrist ganglion cysts.

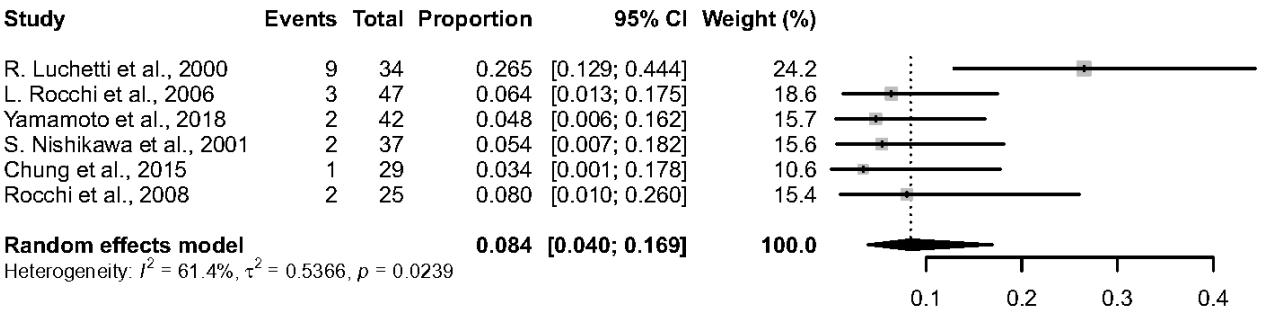


Figure 8

Meta-analysis of conversion rates to open surgery during attempted arthroscopic excision of wrist ganglion cysts.

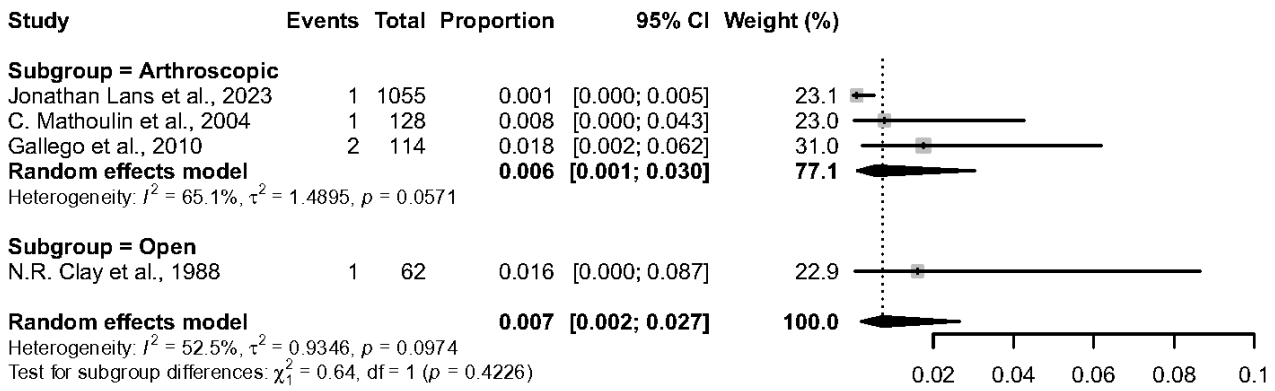


Figure 9

Meta-analysis of hematoma rates comparing arthroscopic excision versus open excision of wrist ganglion cysts.

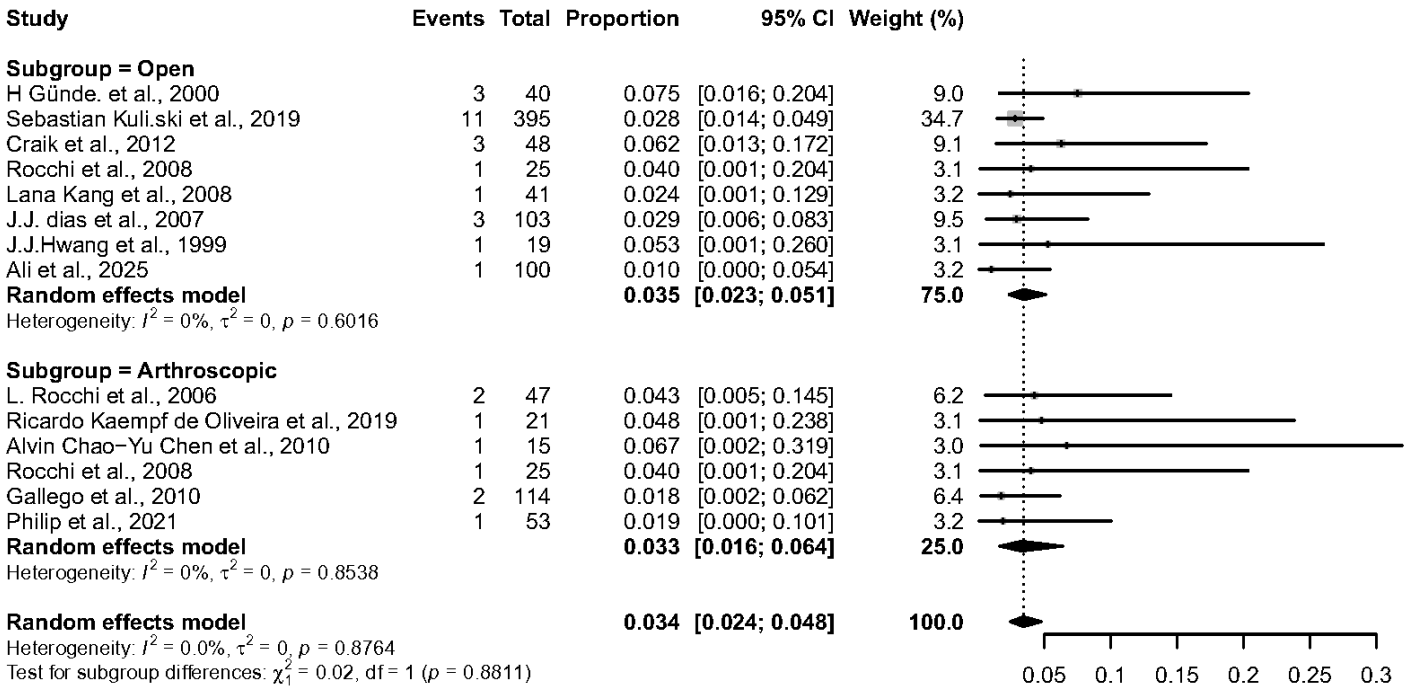


Figure 10

Meta-analysis of nerve injury rates, including temporary sensory or motor loss, comparing arthroscopic excision versus open excision of wrist ganglion cysts.

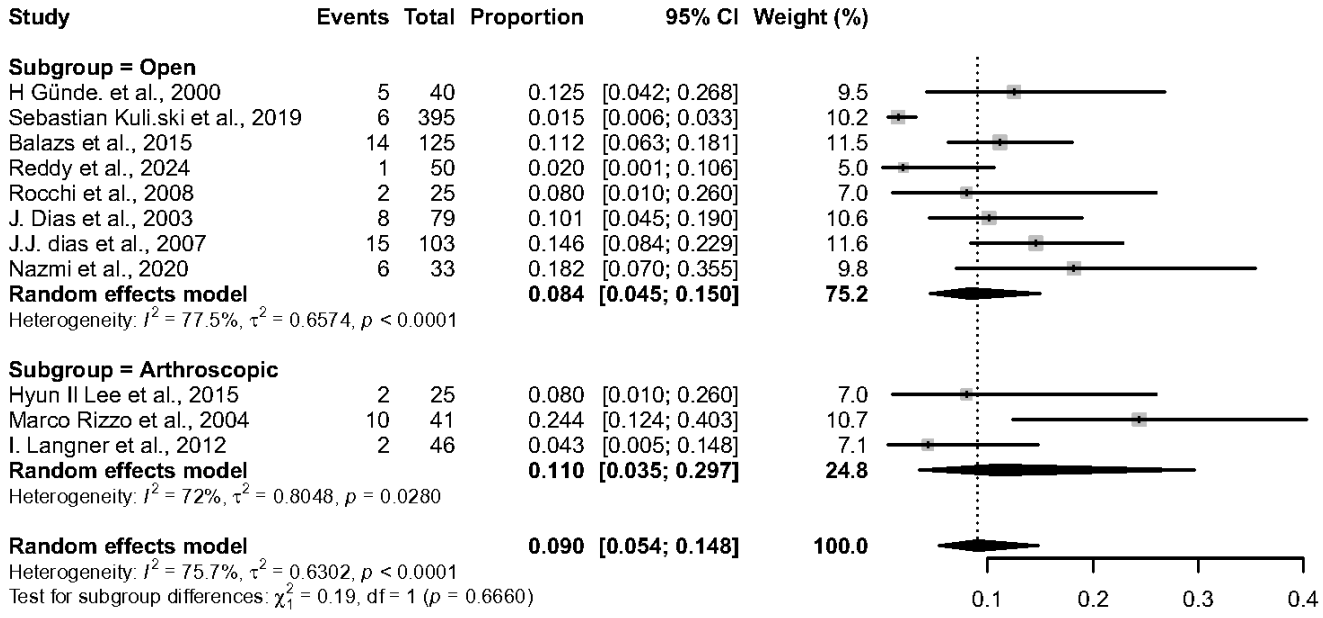


Figure 11

Meta-analysis of joint stiffness rates comparing arthroscopic excision versus open excision of wrist ganglion cysts.

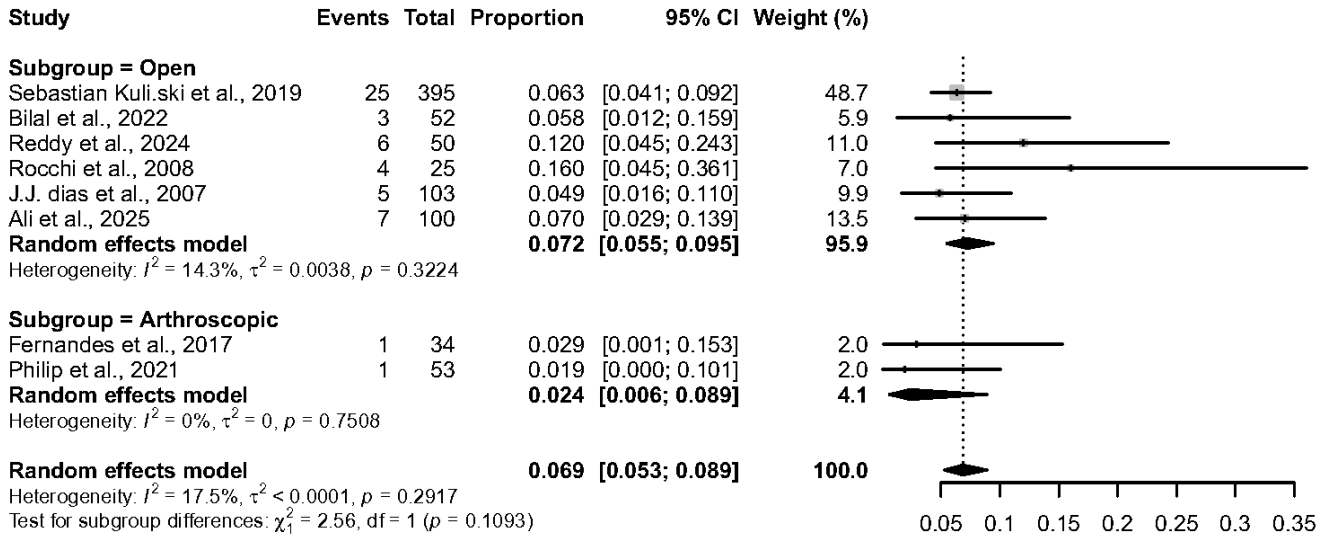


Figure 12

Meta-analysis of abnormal scar formation rates, including hypertrophic scar and keloid, comparing arthroscopic excision versus open excision of wrist ganglion cysts.

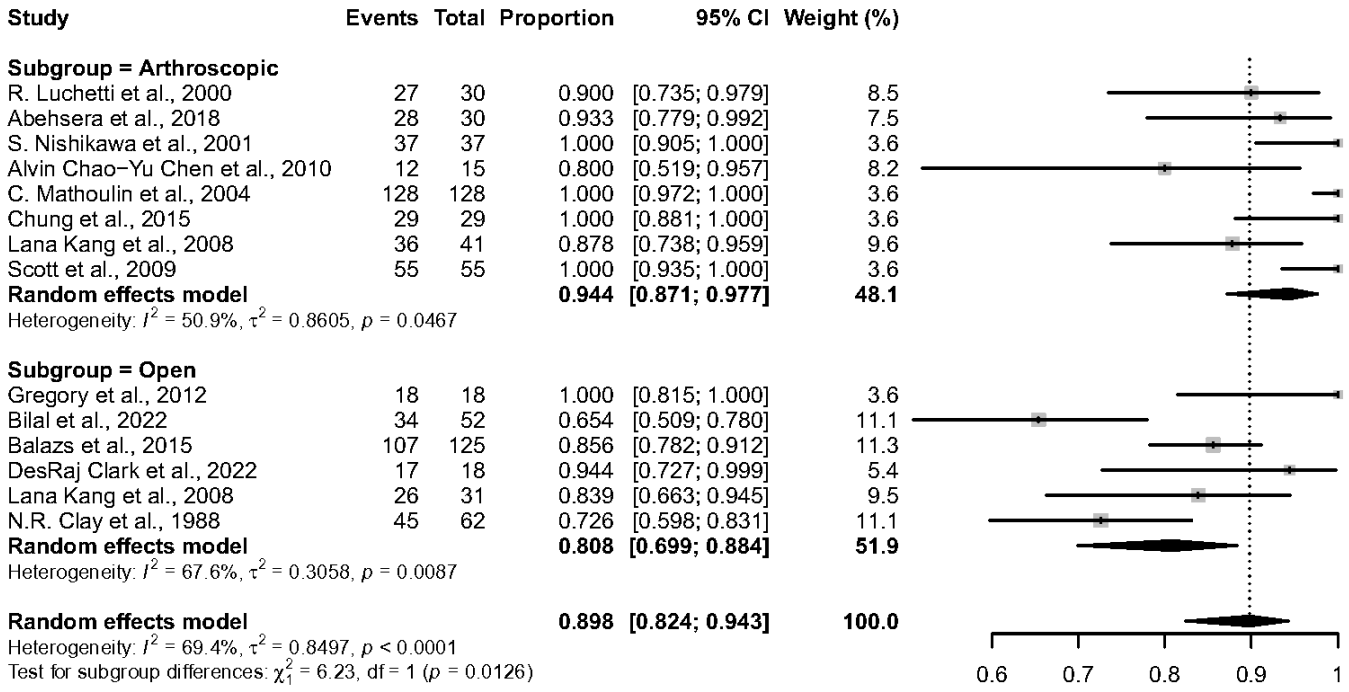


Figure 13

Meta-analysis of pain improvement rates comparing arthroscopic excision versus open excision of wrist ganglion cysts.

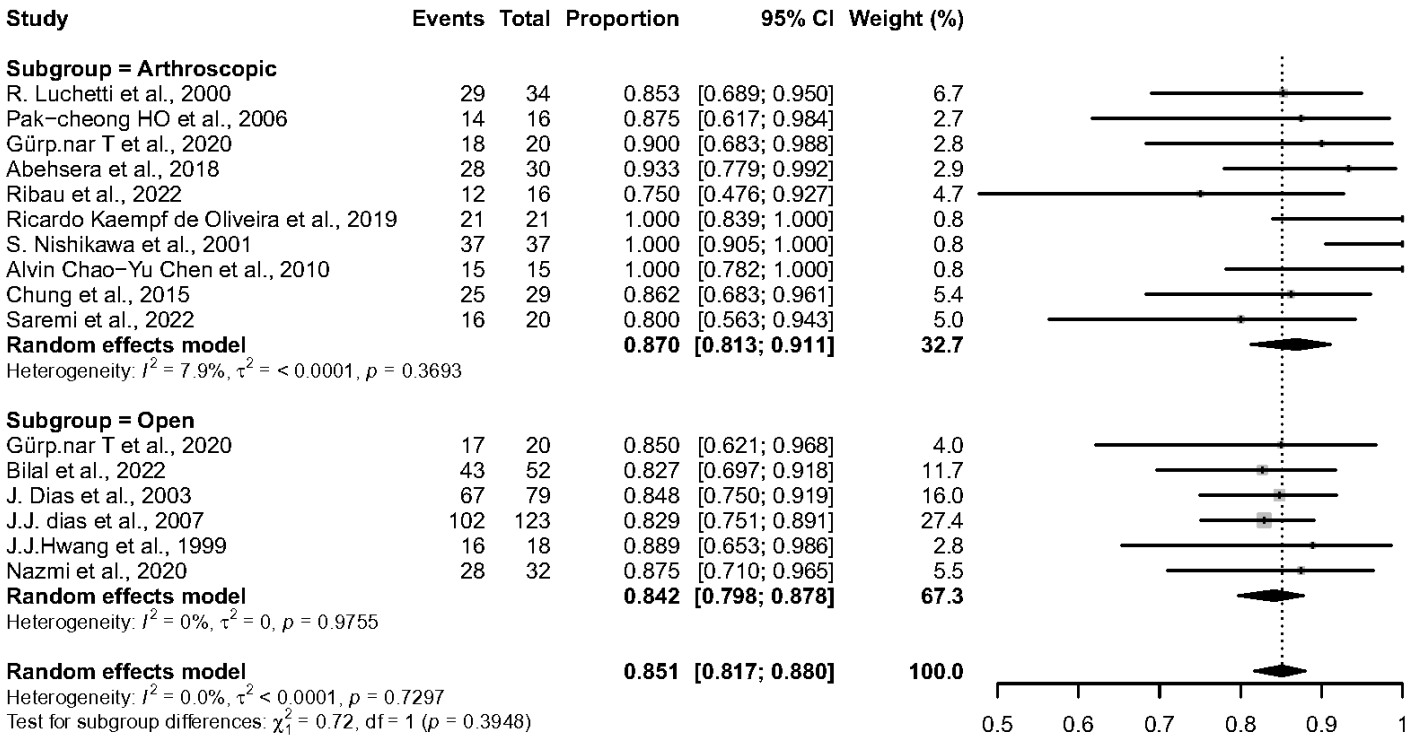


Figure 14

Meta-analysis of patient-reported satisfaction rates comparing arthroscopic excision versus open excision of wrist ganglion cysts.