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Rhinoplasty

Review Article

A Systematic Review and Meta-Analysis of Autologous vs Irradiated Homologous Costal Cartilage Grafts for Dorsal Augmentation Rhinoplasty

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Abstract

Autologous costal cartilage (ACC) is commonly used for dorsal augmentation rhinoplasty because of its availability and strength, despite risks such as hypertrophic scarring and pneumothorax for the patient. Irradiated homologous costal cartilage (IHCC) offers an alternative, potentially mitigating these complications. Previous reviews comparing these materials have been methodologically weak. The aim of this study is to perform a robust systematic review and meta-analysis comparing the outcomes of ACC and IHCC in dorsal augmentation rhinoplasty to guide clinical decision making in nasal reconstruction. Medline, Embase, Google Scholar, and the Cochrane Central Register of Controlled Trials databases were searched. Data extraction and quality assessment were performed by 2 independent authors. The primary outcomes of interest were warping, revision rates, infection rates, and displacement. Methodological quality and risk of bias were assessed using Grading of Recommendations Assessment, Development, and Evaluation and Cochrane's ROBINS I tool, respectively. Thirty-six articles were reviewed, including 1 comparative and 35 single-arm studies (ACC: 29, IHCC: 8), encompassing 2526 patients from 13 countries. Adverse events included warping (ACC: 6%, $P < .0001$; IHCC: 6%, $P < .0001$). Resorption rates were 1% for ACC ($P = .06$) and 3% for IHCC ($P < .0001$). Revision surgery rates were similar (ACC: 4%, $P < .001$; IHCC: 4%, $P < .001$), as were infection rates (ACC: 1.8%, $P = .03$; IHCC: 1.3%, $P = .03$). Current evidence does not demonstrate the superiority of ACC or IHCC for dorsal augmentation rhinoplasty. Both grafts are viable, with the choice guided by patient and surgeon preferences. Prospective, high-quality data with standardized outcomes are needed to improve clinical decision making.

Level of Evidence: 2 (Risk)

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Dorsal augmentation rhinoplasty is a complex reconstructive procedure that involves reshaping the nasal structure, requiring a high degree of technical expertise and the choice of appropriate graft materials.[1] The primary objective of dorsal augmentation is to craft a contoured nasal bridge that harmonizes with the patient's unique facial features.[2] A variety of graft materials can be employed for this purpose, including autologous options such as septal cartilage, auricular cartilage, and costal cartilage, as well as alloplastic implants like silicone.[1] However, it is widely acknowledged among surgeons that there is no universally ideal graft material for dorsal augmentation.[1,3]

Autologous costal cartilage (ACC) grafts are favored among western surgeons because of their greater availability, impressive tensile strength, and are thought to have a lower incidence of postoperative infections, as the patient's own cartilage is used.[1,3] Despite these advantages, ACC grafts have drawbacks, including postoperative pain and complications such as hypertrophic scarring and pneumothorax, which can lead to significant morbidity.[4] To address these concerns, irradiated homologous costal cartilage (IHCC) has emerged as a potential solution.[5] This technique, initially pioneered by Lefkovits in 1940, involves harvesting costal cartilage from a cadaver and exposing it to radiation levels ranging from 30,000 to 50,000 Gy.[5]

Despite the potential benefits of ACC, only one systematic review has compared the efficacy of ACC and IHCC, which is deemed of low quality based on the AMSTAR-2 criteria for assessing systematic reviews.[4,6] (See Table 1, which displays quality of the review according to AMSTAR-2 criteria.) Therefore, the objective of this paper is to provide a rigorous and up-to-date systematic review and meta-analysis that evaluates the effectiveness of ACC vs IHCC grafts used in dorsal augmentation rhinoplasty.

METHODS

The study was prospectively registered a priori with the international prospective register for systematic reviews, PROSPERO (NIHR, London, UK) (registration number: CRD42023445786).

Search Strategy and Selection Criteria

This systematic review and meta-analysis strictly adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[7] and was AMSTAR-2 compliant.[6] A comprehensive search strategy was developed following the Peer Review of Electronic Search Strategies guidance.[8] (See Table 2, which displays the PRISMA flowchart).

One author (D.L.), in collaboration with a literature search expert (K.J.), conducted searches across multiple databases, including Medline, Embase, Google Scholar, and Cochrane Central Register of Controlled Trials, covering studies published up to October 2023. (See Supplemental Table 1, which displays the search strategies).

To identify the totality of relevant literature, we decided to include both retrospective, prospective studies and case series, focusing on the use of ACC or IHCC in rhinoplasty. Key outcomes of interest included warping, infection rate, graft loss, revision surgery, aesthetic outcomes, and patient-reported satisfaction.

We excluded studies that were case reports, contained <4 patients, focused on cleft rhinoplasty, with patients under 18 years old, nonhuman studies, not in English language, studies not centered on costal cartilage.

Table 1. AMSTAR-2 Criterion

Question	Vila et al	
	2020	2024
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Yes	Yes
2. Did the report of the review contain an explicit statement that the review methods were established before?	No	Yes
3. Did the review authors explain their selection of the study designs for inclusion in the review?	No	Yes
4. Did the review authors use a comprehensive literature search strategy?	Unclear	Yes
5. Did the review authors perform study selection in duplicate?	Yes	Yes
6. Did the review authors perform data extraction in duplicate?	Unclear	Yes
7. Did the review authors provide a list of excluded studies and justify them?	Yes	Yes
8. Did the review authors describe the included studies in adequate detail?	Yes	Yes
9. Did the review authors use a satisfactory technique for assessing the RoB in individual studies?	Partial Yes	Yes
10. Did the review authors report on the sources of funding for the studies included in the review?	No	Yes
11. If meta-analysis was performed, did the review authors use appropriate methods for statistical combination?	Yes	Yes
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB on the meta-analysis?	No	Yes
13. Did the review authors account for RoB when interpreting/discussing the results of the review?	No	Yes
14. Did the review authors provide a satisfactory explanation for any heterogeneity observed?	Yes	Yes
15. If quantitative synthesis was performed, did the review authors investigate publication bias?	No	No
16. Did the review authors report any potential sources of conflict of interest or funding for the review?	Yes	Yes

RoB, risk of bias.

Study Selection and Data Extraction

Three authors independently assessed titles and abstracts during the screening phase (D.L., J.J.S., and Z.B.-V.), resolving discrepancies through consensus. Subsequently, 2 authors independently assessed the full texts of potentially eligible papers for inclusion (D.L. and H.U.). In addition, any conflicts were resolved by discussion with a senior reviewer (A.K. and S.V.). The PRISMA flow diagram illustrates the selection process, including studies included and excluded. (See Figure 1, which displays the PRISMA flowchart).

Two authors extracted data from included studies in duplicate (D.L. and H.M.). Study demographics such as author, journal, date,

Table 2. PRISMA Checklist

Section/topic	Item	Checklist item	Reported on page no.
Title			
Title	1	Identify the report as a systematic review, meta-analysis, or both	1
Abstract			
Structured Summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number	1-2
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known	3, 4
Objectives	4	Provide an explicit statement of the questions being addressed with reference to PICOS	3, 4
Methods			
Protocol and registration	5	Indicate if a review protocol exists, where it can be accessed, and, if available, provide registration information, including registration number	4
Eligibility criteria	6	Specify study characteristics (eg, PICOS, length of follow-up) and report characteristics (eg, years considered, language, publication status) used as criteria for eligibility, giving rationale	5
Information sources	7	Describe all information sources (eg, databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched	4
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated	Appendix
Study selection	9	State the process for selecting studies (ie, screening, eligibility, inclusion in systematic review, and, if applicable, inclusion in the meta-analysis)	4
Data collection process	10	Describe the method of data extraction from reports (eg, piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators	5, 6
Data items	11	List and define all variables for which data were sought (eg, PICOS, funding sources) and any assumptions and simplifications made	1, 4
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including whether this was done at the study or outcome level), and how this information is to be used in any data synthesis	6
Summary measures	13	State the principal summary measures (eg, risk ratio, difference in means)	6, 7
Synthesis of results	14	Describe methods of handling data and combining results of studies, including measures of consistency (eg, I^2) for each meta-analysis	6
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (eg, publication bias, selective reporting within studies)	6
Additional analyses	16	Describe methods of additional analyses (eg, sensitivity or subgroup analyses, meta-regression), indicating which were prespecified	NA
Results			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram	Appendix, 7
Study characteristics	18	For each study, present characteristics for which data were extracted (eg, study size, PICOS, follow-up period) and provide citations	7
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12)	Appendix
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and CIs, ideally with a forest plot	Appendix
Synthesis of results	21	Present results of each meta-analysis done, including CIs and measures of consistency	Appendix
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15)	Appendix
Additional analysis	23	Give results of additional analyses, if done (eg, sensitivity or subgroup analyses, meta-regression)	NA

Table 2. Continued

Section/topic	Item	Checklist item	Reported on page no.
Discussion			
Summary of evidence	24	Summarize the main findings, including the strength of evidence for each main outcome; consider relevance to key groups (eg, healthcare providers, users, and policymakers)	13
Limitations	25	Discuss limitations at study and outcome level (eg, risk of bias) and at review level (eg, incomplete retrieval of identified research, reporting bias)	15, 16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research	17, 18
Funding			
Funding	27	Describe sources of funding for the systematic review and other support (eg, supply of data); and the role of funders for the systematic review	1

NA, not applicable; PICOS, participants, interventions, comparisons, outcomes, and study design.

country, study design, total numbers of patients, patient demographics, and clinical outcomes (warping, revision rates, displacement, and infection rates) were extracted.

Quality Assessment

The quality of included studies was independently evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE)[9] tool by 2 authors (H.M. and E.B.-L.). The risk of bias was assessed using the ROBINS-I[10] tool by 2 authors (D.L. and S.V.). Any disparities in quality assessment were resolved through consultation with a senior author (A.K. and S.V.).

Statistical Analysis

Analyses were performed in Stata software, version 18 (StataCorp LLC, College Station, TX) and Microsoft Excel version 16 (Microsoft Corp, Redmond, WA). A random-effects meta-analysis model was employed to account for both within-study and between-study variability, given the anticipated heterogeneity among studies because of differences in surgical techniques, patient populations, and follow-up. For each outcome of interest, including warping, resorption, revision surgery, and infection, proportions were calculated as the number of events divided by the number of patients in each study. These proportions were then transformed using the Freeman–Tukey double arcsine transformation to stabilize the variance.

Heterogeneity among studies was quantified using the I^2 statistic, with values >75% considered indicative of high heterogeneity. In Stata, the "meta" suite of commands was used for the analyses, including "meta esize" for effect size (ES) computation and "meta forestplot" for graphical representations. A *P*-value of <.05 was considered significant for all analyses, and 95% CIs were reported for all effect estimates.

RESULTS

The literature search identified 1527 studies. After title and abstract screening, 98 studies were deemed eligible for full-text review. Thirty-six articles were selected for this review after full-text screening.[11-46] This included 1 comparative study[11] and 35 single-arm studies (ACC 28 single arm[12-39] and IHCC 7 single arm[40-46]).

No randomized controlled trials were identified, either in our search or in previous reviews to date.[2,4,5] The 36 selected papers included a total of 2526 patients (ACC: 1941; IHCC: 585) with a mean age of 30.42 years, spanning 13 countries across 4 continents. Most studies originated from Turkey,[17,20,21,24,31-33,46] South Korea,[11,18,19,26,28] and the United States.[29,40-45] The studies primarily focused on dorsal augmentation rhinoplasty, with some also additionally addressing tip enhancement and nasal length.[11,18,28,34-36,38] Most procedures were performed using the open rhinoplasty technique.[12,15,16,18-20] Additionally, some patients underwent techniques such as the counterbalance technique,[39] the 3-component cartilage framework technique,[15] and multilayer CCG to prevent warping.[26] The sample sizes were generally small, with surgeries often performed by the lead author. This review also includes several studies on ethnic rhinoplasty.[26,28,34-38]

This review was deemed high quality according to the AMSTAR-2 criteria. (See Table 1, which displays the quality of this review. See Figures 2-5, which display the graphs for the meta-analysis. See Table 3 and Supplemental Table 2, which display the summary of the demographics and key outcomes of the papers).

Clinical Outcomes

Warping

Warping was notable in the ACC group, with 96 cases out of 1941 patients (4.95%). In the IHCC group, 21 out of 585 patients (3.58%) experienced warping. Only 3 studies provided clear definitions of warping.[11,16,39]

A meta-analysis of 22 studies on warping yielded an ES of 0.06 (95% CI, 0.02-0.12; $P = .0001$) for ACC and 0.05 (95% CI, 0.00-0.12; $P = .05$) for IHCC with no significant difference between the 2 groups ($P = .796$). Significant heterogeneity was observed across studies, particularly for ACC, with $I^2 > 80\%$, indicating considerable variability in warping outcomes between different studies.

Resorption

Cartilage resorption was reported in 18 out of 1941 ACC patients (0.93%) and in 81 out of 585 IHCC patients (13.84%). The meta-analysis yielded a pooled ES of 0.01 (95% CI, 0.00-0.03) for ACC and 0.03 (95% CI, 0.00-0.11) for IHCC. Although the ACC result was marginally nonsignificant ($P = .06$), resorption in the IHCC group

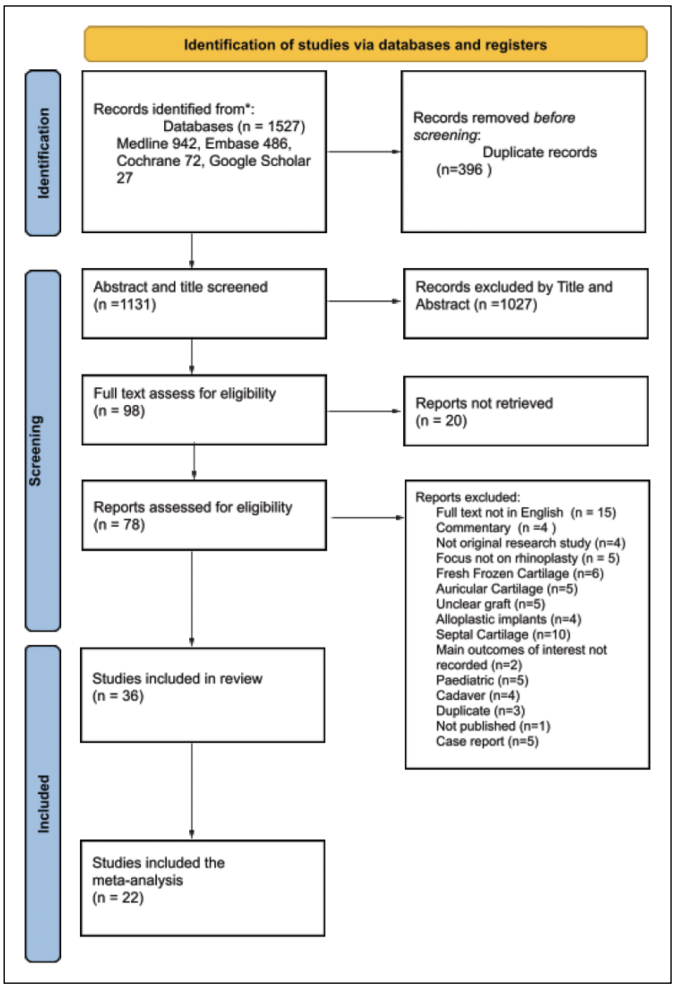

Figure 1. Displays the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

was statistically significant ($P = .00$). There was no significant difference in overall resorption rates between ACC and IHCC when considering all studies. However, higher variability was observed in IHCC studies ($I^2 = 73.37\%$) compared with more consistent outcomes in ACC studies ($I^2 = 38.19\%$).

Revision Surgery

In the ACC group, 67 out of 1941 patients (3.45%) required revision surgery, whereas in the IHCC group, 17 out of 585 patients (2.91%) underwent revision procedures.

For the ACC group, the ES was 0.04 (95% CI, 0.00-0.09), with a *P*-value of <.001, indicating a statistically significant result. Similarly, the IHCC group had an ES of 0.07 (95% CI, 0.03-0.11) and a *P*-value of .80, showing no statistical significance. There was high heterogeneity for ACC ($I^2 = 85.75\%$), but IHCC showed no heterogeneity ($I^2 = 0\%$). When comparing ACC and IHCC directly, there was no significant difference in revision rates ($P = .411$).

Infection

In the ACC group, 35 out of 1941 patients (1.80%) reported infections, whereas in the IHCC group, 12 out of 585 patients (2.05%) experienced infections. Infection cases were reported in studies from nearly all countries included in the review.

A meta-analysis for infection rates showed that the ACC group had an infection rate of 3%, with an ES of 0.03 (95% CI, 0.00-0.07), and a *P*-value of <.001, indicating statistical significance. However, ACC infection outcomes showed high variability ($I^2 = 75.67\%$).

In the IHCC group, the infection rate was 1%, with an ES of 0.01 (95% CI, 0.00-0.03), and a *P*-value of .49, indicating no statistical significance. IHCC exhibited no variability ($I^2 = 0\%$), indicating consistent infection outcomes across studies. Despite differences in infection rates, the meta-analysis showed no significant difference between ACC and IHCC for infection ($P = .482$).

Displacement and Extrusion

Displacement occurred in 23 out of 1941 ACC patients (1.18%) and 5 out of 585 IHCC patients (0.85%). None of the studies defined displacement in their methods.

Extrusion was rare, with 9 out of 1941 ACC patients (0.46%) and 1 out of 585 IHCC patients (0.17%). Definitions for extrusion were not documented in the studies.

Nasal Obstruction

No cases of nasal obstruction were documented in both the IHCC and ACC groups, nor was this a variable of focus.

Complications in Autologous Costal Cartilage Retrieval

Hypertrophic scar formation occurred in 15 out of 1941 patients (0.77%), and pneumothorax was reported in 6 out of 1941 patients (0.31%) among those who had ACC.

Aesthetic and Functional Outcomes

Aesthetic and functional outcomes were generally favorable across both ACC and IHCC groups, with high patient satisfaction rates in most studies. Only 3 studies used blinded assessors,[11,15,35] and outcome assessment was subjective. Only a few papers used validated measures, such as Rhinoplasty Outcome Evaluation questionnaire[11,27,37,36] and Likert scale.[12,39] (Supplemental Table 3, which displays the method of graft harvest, subjective, and objective methods used to evaluate aesthetic function).

Quality of Evidence, Risk of Bias, and Heterogeneity

For all of the studies, the quality of evidence, assessed using the GRADE system, was deemed low because of significant limitations, including bias, inconsistency, and heterogeneity. The lack of standardized outcome measures, small nonrandomized studies, and the absence of direct comparisons between ACC and IHCC led to a high risk of bias in most studies. The ROBINS-I tool showed that most studies were at high risk of bias, particularly because of confounding factors, unclear patient selection, and poor outcome reporting. (See Table 4, which displays the risk of bias assessment).

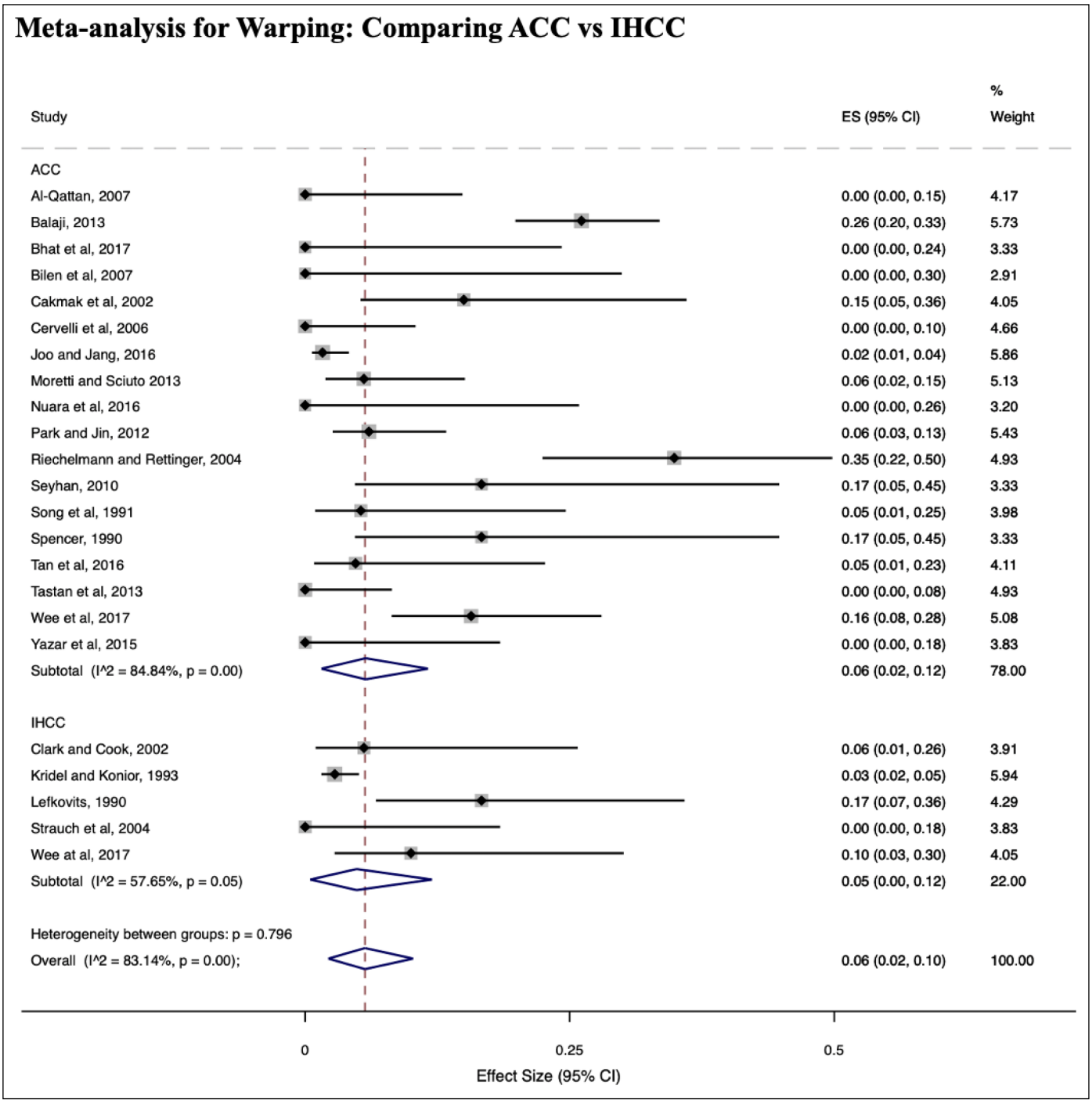

Figure 2. Meta-analysis for warping comparing autologous costal cartilage vs irradiated homologous costal cartilage. ACC, Autologous Costal Cartilage; IHCC, Irradiated Homologous Costal Cartilage.

DISCUSSION

This systematic review and meta-analysis provides the first, methodologically robust evaluation of ACC vs IHCC grafts for dorsal augmentation in rhinoplasty, as judged by AMSTAR-2 criteria.[4,6] It encompasses a wide range of studies from multiple countries. This paper looks at key outcomes, such as warping, resorption, revision surgery, and infection rates postrhinoplasty. Given the importance of graft materials in both reconstructive and aesthetic rhinoplasty, the aim of this paper was to offer clarity on the most suitable graft material amid the lack of consensus.[1,3]

However, it is essential to note that no randomized controlled trials were identified on this topic, and most papers included in this review are of lower quality, consisting of retrospective studies and case

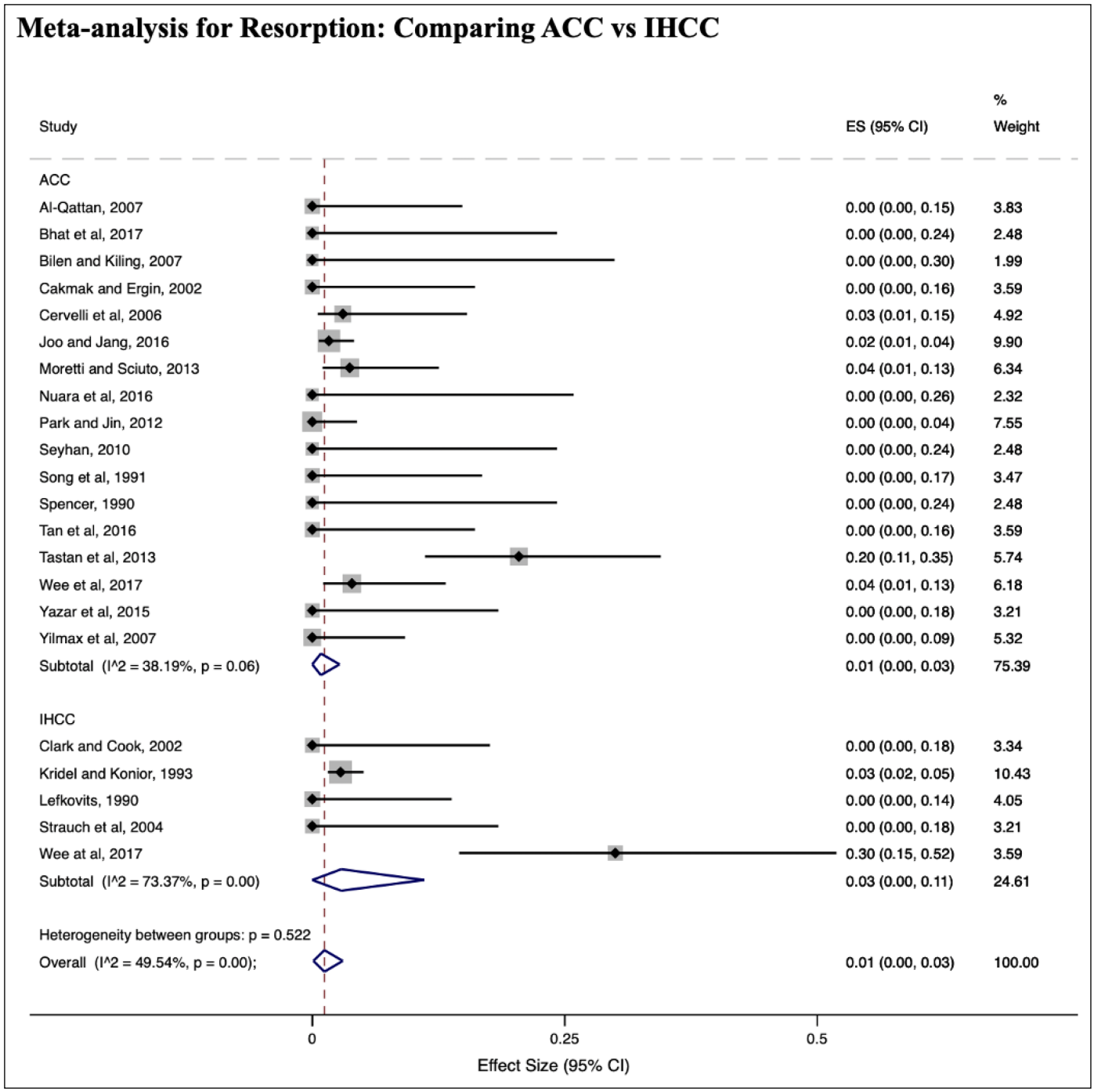

Figure 3. Meta-analysis for reabsorption comparing autologous costal cartilage vs irradiated homologous costal cartilage. ACC, Autologous Costal Cartilage; IHCC, Irradiated Homologous Costal Cartilage.

series.[11-46] This contributes to a high risk of bias, because of factors such as selection bias, confounding from variations in surgical techniques, and bias in the measurement of outcomes. Consequently, our results should be interpreted with caution.

The ACC grafts exhibited particularly high heterogeneity for several outcomes, particularly infection rates ($I^2 = 75.67\%$) and revision rates ($I^2 = 85.75\%$), suggesting significant variability between studies. This variability may occur because of differences in surgical techniques, patient demographics, or follow-up durations across the included studies.[11-39] These inconsistencies introduce challenges in predicting how ACC performs across clinical settings, potentially impacting clinical decision making.

In contrast, IHCC demonstrated little to no heterogeneity for infection and revision rates ($I^2 = 0.00\%$), indicating that IHCC yielded more

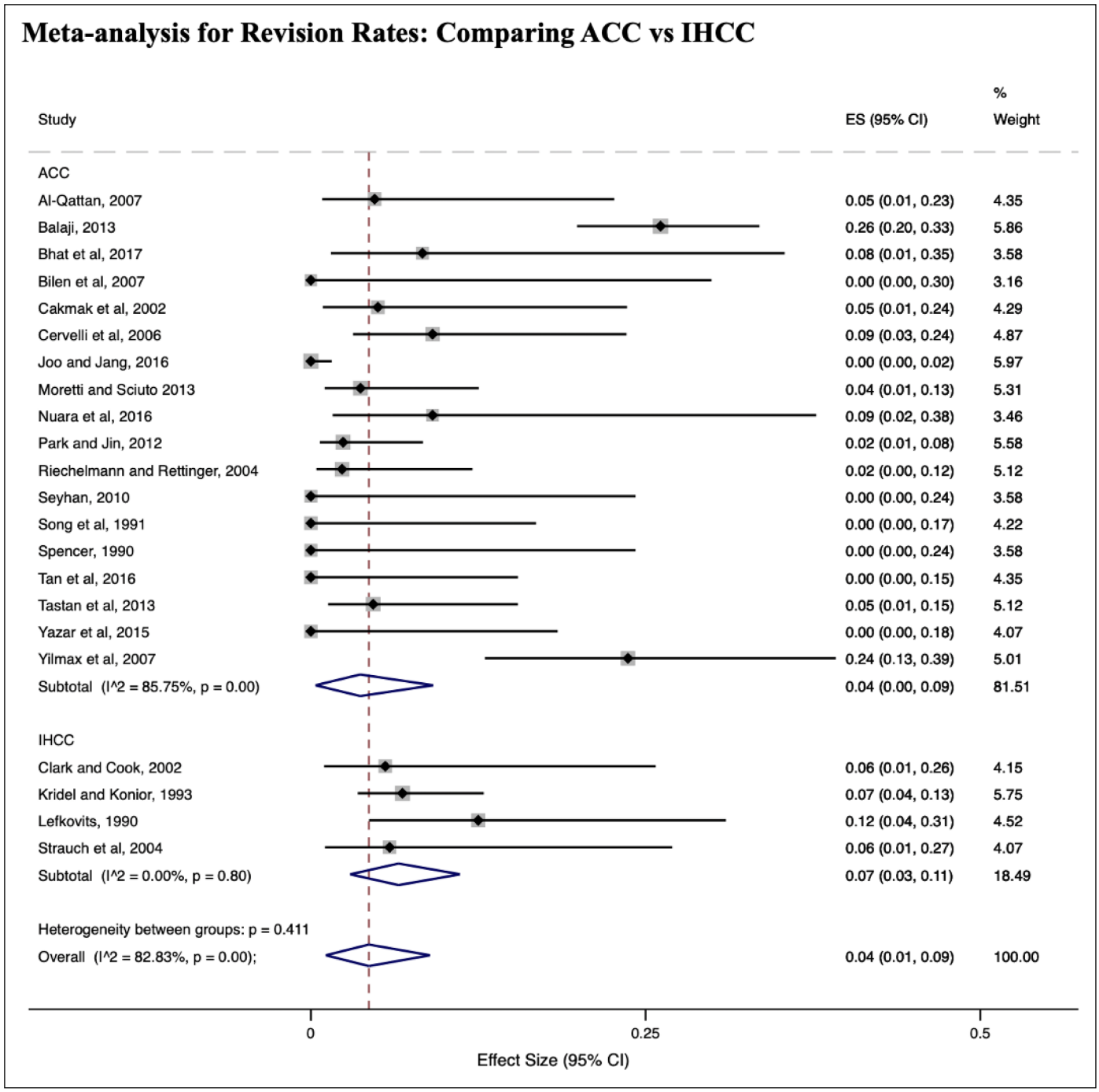

Figure 4. Meta-analysis for revision rates comparing autologous costal cartilage vs irradiated homologous costal cartilage. ACC, Autologous Costal Cartilage; IHCC, Irradiated Homologous Costal Cartilage.

consistent results across studies. The standardized preparation of IHCC through irradiation, along with uniform handling protocols, could be contributing to these consistent outcomes.[5]

Nevertheless, when comparing ACC vs IHCC, no statistically significant differences were identified between these grafts across any of the major outcomes. These findings suggest that both graft materials perform similarly in terms of complication rates. However, IHCC grafts may offer more predictable outcomes because of lower variability, and ACC grafts could possibly be less predictable in clinical practice particularly, for outcomes like infection and revision rates.

In the literature, a key disadvantage of using ACC is the risk of complications, such as pneumothorax and hypertrophic scar formation at the donor site.[1,3] However, our findings suggest that these risks are relatively low, likely depending on the surgical technique and the surgeon's experience. Future studies could

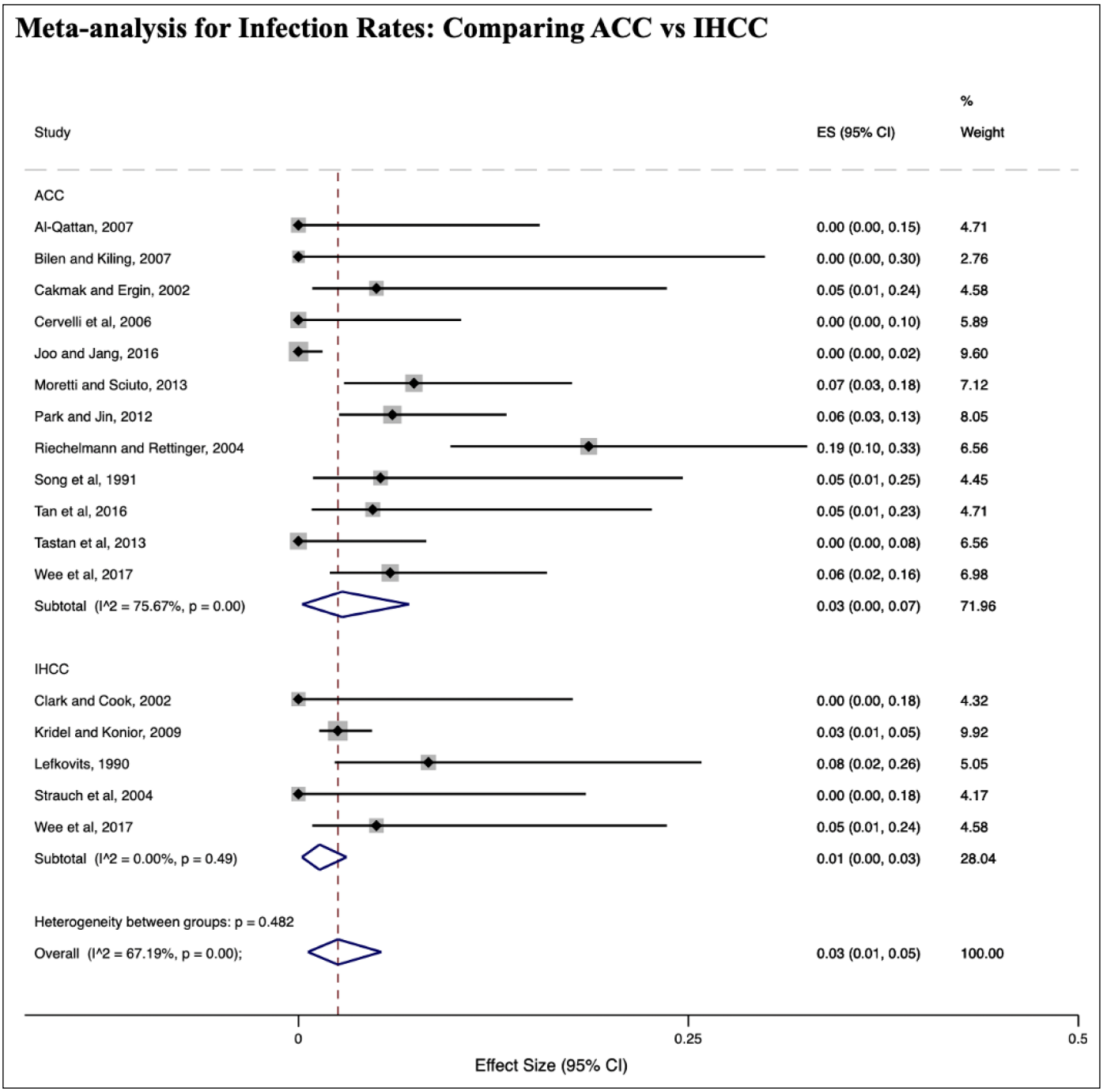

Figure 5. Meta-analysis for infection rates comparing autologous costal cartilage vs irradiated homologous costal cartilage. ACC, Autologous Costal Cartilage; IHCC, Irradiated Homologous Costal Cartilage.

explore how ACC harvesting impacts patients' recovery times and morbidity.

Wee et al, the only comparative study identified in this review, examined the histological differences between ACC and IHCC grafts.[11] Their findings revealed that ACC maintained more uniform, larger chondrocytes, as well as denser collagen and proteoglycan content compared with IHCC.[11] This difference is likely because of the sterilization process IHCC undergoes, which involves exposure to gamma radiation.[1,3,5] Although gamma radiation ensures sterilization, it may also alter the structural integrity of the cartilage, leading to a less uniform and dense tissue composition, potentially increasing the risk of resorption associated with IHCC.[11,47]

A new trend has emerged with the use of fresh frozen cartilage (FFC) for augmentation rhinoplasty, which is harvested and preserved through freezing.[47-49] This preservation method could retain more of the cartilage's intrinsic biological and mechanical

Table 3. Demographic Characteristics of the Included Studies and Complication Rates for IHCC

Ref.	Author	Year	Country	Total patients	Age, mean (range)	Follow-up, mean (range), month	Type of graft	Primary rhinoplasty	Secondary revision	Trauma	Congenital	Warping	Resorption	Revision	Infection	Displacement	Extrusion	Funding
11	Jee Hye Wee	2017	South Korea	20	35.4 (15-55)	38.8 (22-53)	Dorsal graft	NR	10	NR	NR	2	6	NR	1	NR	NR	Funded disclosed
40	Murakami C	1991	US	18	39.2 (NR)	33.6 (NR)	Dorsal graft	NR	4	1	NR	1	0	1	0	2	0	Not disclosed
41	Strauch B	2004	US	17	NR	NR (84-168)	Multiple graft	NR	NR	NR	NR	0	0	0	0	1	0	Not disclosed
42	Kridel R	2009	US	357	37.3 (24.7-49.9)	161.4 (127.44-195.36)	Multiple graft	83	274	13	10	10	19	9	3	0	0	Not disclosed
43	Clark J	2002	US	18	NR	26 (13-48)	Dorsal graft	0	18	0	0	1	1	1	0	NR	NR	Not disclosed
44	Lefkovits G	1990	US	24	31 (16-49)	NR (1-27)	Dorsal graft	13	11	4	10	4	0	NR	2	NR	NR	Not disclosed
45	Menger D	2010	The Netherlands	66	39 (15-68)	51 (18-96)	Multiple graft	10	56	NR	NR	2	55	6	6	2	0	Not disclosed
46	Demirkan F	2003	Turkey	65	28 (NR)	33 (6-49)	Multiple graft	13	24	21	7	1	NR	NR	0	NR	1	Not disclosed

NR, not recorded.

properties, as it avoids the harsh effects of radiation.[47] Future studies could explore long-term histological comparisons between ACC, IHCC, and FFC to assess their resorption rates and overall stability.

Graft material, while important, is not the sole factor influencing rhinoplasty success.[1,3] The choice of graft material is closely linked with several other factors, such as the patient's anatomy, the surgeon's experience and preference, the graft harvesting technique, and carving.[1,3,11,15,18,39] These elements work together to ensure successful outcomes, meaning that selecting the right material should always be done in conjunction with a comprehensive understanding of the individual patient.[1,3]

Limitations

This review has several limitations, primarily related to the quality and consistency of the available literature, which complicates the ability to draw definitive conclusions. One significant issue is that many studies did not clearly define key outcomes, such as warping, in their methodologies.[12-14,16,17,19-25,27-38] This inconsistency makes it difficult to ascertain whether all authors interpreted these outcomes in the same way. Additionally, certain outcomes, such as contour irregularity and displacement, were examined in some studies but not in others, contributing to variability in reporting across the included literature.[13,23,26,29,30,37,40,42,46]

For instance, Menger and Nolst Trenite categorize resorption into different severities, such as "moderate" and "complete" and reported the highest rate of resorption among the papers.[45] This detailed classification provided a clearer understanding of extent resorption. In contrast, the lack of such categorization in other studies may have led to underreported resorption rates, as they did not account for varying degrees of severity. The inconsistency in reporting highlights the need for standardized definitions and assessments in future studies to provide clearer and more comparable data across different graft materials.

Additionally, outcome reporting after rhinoplasty was inconsistent, and only a few studies used blinded assessors, which increased the risk of bias.[11,15,39] Measures of patient satisfaction were also applied inconsistently, with only a limited number of studies utilizing standardized patient-reported outcome measures (PROMs), which makes it challenging to evaluate the subjective success of the procedures comprehensively.[11,12,27,37,36]

Furthermore, the included studies often involved diverse patient population groups, such as patients who underwent rhinoplasty as primary, revisions, and because of other reasons, such as congenital and trauma causes. The absence of separate analyses for primary and secondary rhinoplasty outcomes based on etiology limits the ability to determine which graft type may be more suitable in different clinical scenarios. As such, future studies should consider stratifying patients more clearly to yield insights specific to each subgroup.

Future Directions

Future research should focus on large cohort studies that directly compare ACC and IHCC while accounting for confounding factors, such as patient demographics, surgical techniques, and graft preparation methods. Long-term follow-up is essential to evaluate the incidence of complications, such as warping, resorption, and revision rates, as these outcomes may change over time. Subgroup analyses should be performed to assess how different cartilage graft types perform in various demographic groups, including different ethnicities and age ranges.

Future studies should also prioritize PROMs to better evaluate patient satisfaction and quality of life.[50-52] There should be further exploration of various cartilage grafting techniques, such as laminated, crushed, diced, or the sandwich technique, to determine which approach provides the best long-term stability and aesthetic outcomes.[1,53]

Table 4. Summary of the Risk of Bias Assessment

Study	Confounding	Selection	Intervention classification	Deviations from intended interventions	Missing data	Measurement of outcomes	Selection of the reported result	Overall bias
Jee Hye Wee 2017	High	Unclear	Unclear	Low	Low	Low	Low	Serious
Wafa A 2018	High	Unclear	NA	Low	Low	Moderate	Moderate	Serious
Al-Qattan 2007	High	Unclear	NA	Low	Low	Moderate	Low	Serious
Song 1991	High	Unclear	NA	Low	Unclear	Unclear	Unclear	Unclear
Hsiao Y 2013	High	Unclear	NA	Low	Unclear	Serious	Unclear	Unclear
Balaji, S 2013	High	Unclear	NA	Low	Unclear	Serious	Moderate	Serious
Cakmak 2002	High	Unclear	NA	Low	Low	Unclear	Moderate	Serious
Lee 2021	High	Unclear	NA	Low	Unclear	Low	Low	Serious
Park 2012	High	Unclear	NA	Low	Unclear	Moderate	Unclear	Serious
Bilen 2007	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious
Yilmaz 2007	High	Unclear	NA	Low	Unclear	Unclear	Moderate	Serious
Spencer 1990	High	Unclear	NA	Low	Unclear	Unclear	Unclear	Unclear
Cervelli 2006	High	Unclear	NA	Low	Unclear	Unclear	Unclear	Unclear
Seyhan 2010	High	Unclear	NA	Low	Unclear	Moderate	Moderate	Serious
Moretti 2013	High	Unclear	NA	Low	Low	Serious	Unclear	Serious
Namgoong 2020	High	Unclear	NA	Low	Low	Low	Low	Serious
Bhat 2017	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious
Joo 2016	High	Unclear	NA	Low	Low	Moderate	Low	Serious
Nuara 2016	High	Unclear	NA	Low	Low	Serious	Unclear	Serious
Riechelmann 2004	High	Unclear	NA	Low	Low	Moderate	Moderate	Serious
Tan 2006	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious
Tastan 2013	High	Unclear	NA	Low	Low	Serious	Unclear	Serious
Yazar 2015	High	Unclear	NA	Low	Low	Moderate	Unclear	Serious
Li 2023	High	Unclear	NA	Low	Unclear	Low	Moderate	Serious
Wang 2021	High	Unclear	NA	Low	Unclear	Moderate	Low	Serious
Fu 2023	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious
Wei 2020	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious
Zeng 2020	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious
Agrawal 2015	High	Unclear	NA	Low	Low	Moderate	Low	Serious
Murakami 1991	High	Unclear	NA	Low	Unclear	Serious	Low	Serious
Strauch 2004	High	Unclear	NA	Low	Unclear	Serious	Low	Serious
Kridel 2009	High	Unclear	NA	Low	Low	Serious	Unclear	Serious
Clark 2002	High	Unclear	NA	Low	Low	Serious	Low	Serious
Lefkovits 1990	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious

Table 4. Continued

Study	Confounding	Selection	Intervention classification	Deviations from intended interventions	Missing data	Measurement of outcomes	Selection of the reported result	Overall bias
Menger 2010	High	Unclear	NA	Low	Low	Serious	Unclear	Serious
Demirkan 2003	High	Unclear	NA	Low	Unclear	Serious	Unclear	Serious

NA, not applicable.

CONCLUSIONS

Our findings demonstrate that both ACC and IHCC are viable options for dorsal augmentation in rhinoplasty, with no significant differences in complication rates. However, it is essential to note that graft material alone does not determine the success of surgical outcome. The choice of graft is linked to other factors, including the patient's anatomy, the surgeon's experience and preferences, and the techniques used for graft harvesting and carving. Prospective, high-quality studies with standardized reporting are needed to better inform graft selection and support evidence-based decision making. Additionally, future research should explore alternative graft options, such as FFC, to provide further insights into the most effective materials for rhinoplasty procedures.

Supplemental Material

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