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Systematic review

Autogenous grafts for reconstruction arthroplasty in temporomandibular joint ankylosis: a systematic review and meta-analysis

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Abstract

Autogenous methods for reconstruction arthroplasty (RA) for the surgical management of the temporomandibular joint (TMJ) have been extensively reported. The present review was aimed to systematically review and pool data on clinical outcomes of autogenous grafts for RA in subjects with TMJ ankylosis. Major electronic databases and prominent subject-specific journals were searched up to December 2020. Randomised controlled trials (RCT), cohort studies, and retrospective studies reporting outcomes of autogenous grafts for RA in TMJ ankylosis were included. A total of 35 studies with 700 subjects was included. The most commonly employed grafts were costochondral grafts (CCG) and coronoid process grafts. Postoperative change in maximum incisor opening (MIO) was comparable amongst all grafts and was in the clinically acceptable range (27.21–31.38 mm). The recurrence rate was comparable for all grafts and was ≈ 8% except for coronoid grafts, where the recurrence rate was 2.98%. Growth assessment for CCG revealed that 55.89%, 30.89%, and 13.24% of subjects depicted optimal growth, overgrowth, and undergrowth, respectively. Within the limitations of the present review, the recurrence rate for all grafts was comparable except for coronoid graft, which depicted least recurrence rate and resultant postoperative change in MIO was in the clinically acceptable range.

Keywords: TMJ ankylosis; Reconstruction arthroplasty; Autogenous grafts; Costochondral; Coronoid

Introduction

Temporomandibular joint (TMJ) ankylosis is a restraining ailment, which significantly affects the quality of life by limiting the ability to perform routine daily activities and interferes with facial growth, resulting in deformities and poor airway space.[1]

The management of TMJ ankylosis is surgical, and the targeted outcomes include functional rehabilitation of the TMJ with improved maximum incisor opening (MIO) with improved facial profile, and regularisation of mandibular growth. The extensive resection of the joint and poor growth often culminates in the need to reconstruct the joint, which can either be achieved by placing grafts, prosthetic implants, or by using distraction osteogenesis (DO).[2–4] The ideally reconstructed joint should be able to mimic natural condylar anatomy and should be able to function well to allow a normal symptom-free quality of life. At the same time, it should permit adaptive remodelling and growth. The struggles to reach the ideal goals of TMJ reconstruction have led to an overabundance of treatment possibilities, such as autogenous reconstruction, alloplastic prosthetic implants, and DO. Among these, reconstruction using autogenous grafts is the most preferred option, despite being associated with several problems. A wide array of autogenous tissues, such as costochondral grafts (CCG), sternoclavicular joint (SCG), coronoid process, metatarsal head, fibula and posterior border of the ramus have been reported to be used for reconstruction of the condylar head.[5] There is a dilemma in choosing the

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appropriate surgical approach to balance the trade-off between relapse rate and technical difficulty in different degrees of complexities of malformation.[2–3]

Bearing in mind the lack of evidence and availability of a good number of heterogeneous studies on autogenous grafts for condylar reconstruction, the present systematic review has been performed to report on surgical outcomes of autogenous grafts for condylar reconstruction in subjects with TMJ ankylosis.

Material and methods

Protocol

The present review was planned a priori and is being reported as per PRISMA guidelines.

Research question and eligibility criteria

As per the PICOS schema, randomised controlled trials (RCTs), quasi-randomised controlled trials, clinically controlled trials, non-randomised cohort studies, and retrospective studies (S) on various types of autogenous grafts (I, C) for condylar reconstruction in subjects with TMJ ankylosis (P) assessing re-ankylosis or postoperative changes in MIO after a follow-up period of $\geq$12 months were included.

The studies on populations undergoing condylar reconstruction for aetiologies other than TMJ ankylosis or TMJ ankylosis due to systemic diseases, such as osteoarthritis, were not included. Also, the studies where the number of subjects was <5 were excluded.

Information sources and literature search

All major electronic databases were searched using a combination of various terms using the Boolean operators AND and OR, such as TMJ, TMJ ankylosis, temporomandibular joint, reconstruction arthroplasty, costochondral graft, coronoid graft, sternoclavicular graft, iliac crest graft, metatarsal graft, autogenous graft (Appendix 1). Hand-searching was performed for main-stream journals of the subject of oral and maxillofacial surgery. Additionally, the reference lists of all included studies were explored to locate any potentially eligible studies. Two investigators (MN and SD) independently performed the searches and identified the potentially eligible studies in duplication. Any disagreements were resolved by discussion amongst all the investigators.

Selection of the included studies

The results of the search were managed using reference management software (Endnote X9.3.2 for windows, Clarivate analytics). Duplicates were removed, and the titles, abstracts and full texts of the remaining articles were screened independently by two authors (MN and SD) to decide upon the inclusion in the systematic review. Any disagreements were resolved by mutual discussion among three authors.

Data collection process

A pre-designed excel spreadsheet (Microsoft Excel, Microsoft Office 10) was piloted and employed for data extraction by two authors independently (MN and SD) to record study characteristics, type of intervention, and details of study participants. The difference between preoperative and postoperative MIO was calculated to be reported as a postoperative change in MIO (δ MIO).[3]

Risk of bias assessment

The Newcastle Ottawa Scale (NOS) was used to assess the quality of included studies, and accordingly, a numeric NOS score was assigned.[6]

Quantitative synthesis

Binary outcomes were expressed as a risk difference with a 95% confidence interval (95% CI), and continuous outcomes were expressed as a mean difference with 95% CI. In case of low heterogeneity ($p > 0.05$ or $I^2 \leq 24\%$), a fixed-effect model was used; otherwise, a random-effect model was used. The chi squared and I^2 tests were used to calculate statistical heterogeneity and a p value of <0.05 as per the chi squared test meant high heterogeneity. Funnel plots were constructed to assess any publication bias. Leave one out approach by removing studies with a higher weight was employed to perform sensitivity analysis. All statistical analyses were performed using RevMan 5.3 (Cochrane Collaboration) and MedCalc software (MedCalc software Ltd).

Results

Selection of the studies

After the removal of duplicates 8,681 records were identified. Following the screening of titles and abstracts, 71 records were deemed suitable for full-text reading. After the full-text reading of these records, 36 were further excluded (Appendix 2), and only 35 were included for the qualitative synthesis (Fig. 1). The value of Cohen's Kappa coefficient for inter-examiner reliability among the two reviewers for study selection was determined to be 0.97.

Characteristics of included studies and interventions and risk of bias assessment (Appendix 3)

Thirty-five studies (1 RCT, 9 non-RCTs, and 25 retrospective studies) were found to be eligible to be included in the present review. However, only 8 studies[7–14] included comparative arms, and the rest were single-arm interventional studies. The study population comprised of 700 subjects. The included subjects received a variety of autogenous grafts

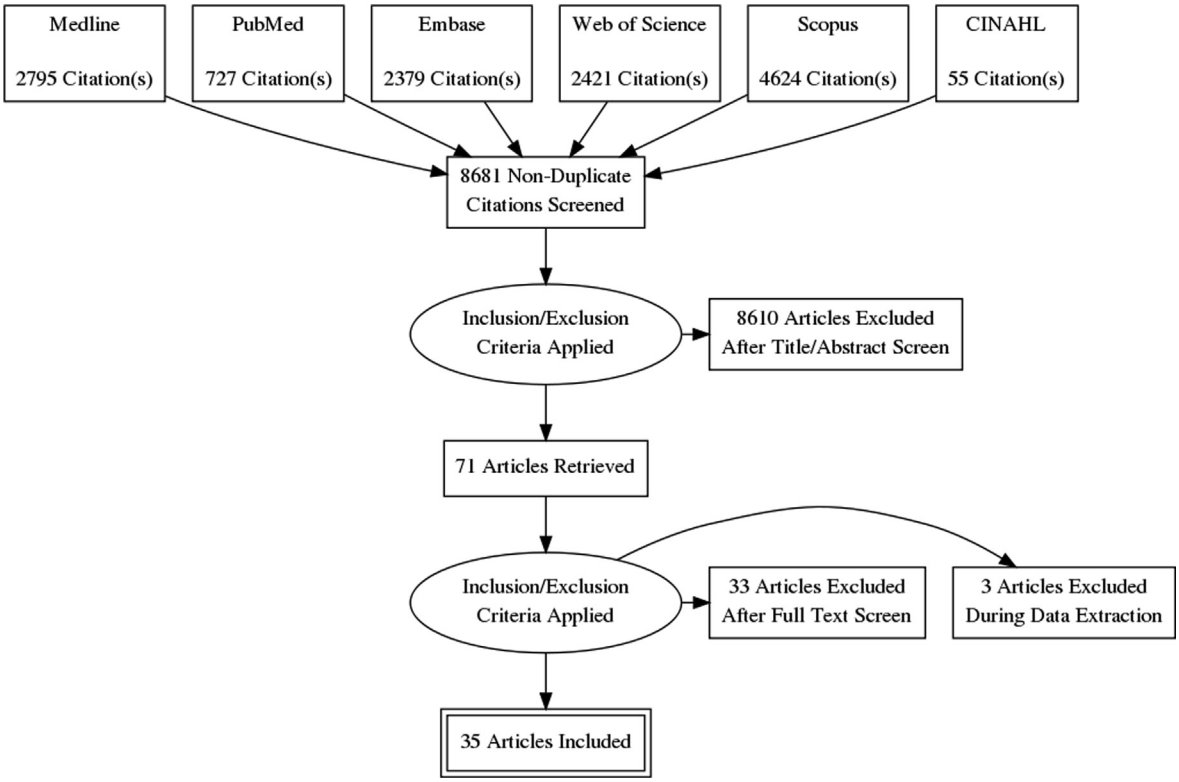

Fig. 1. The PRISMA flowchart.

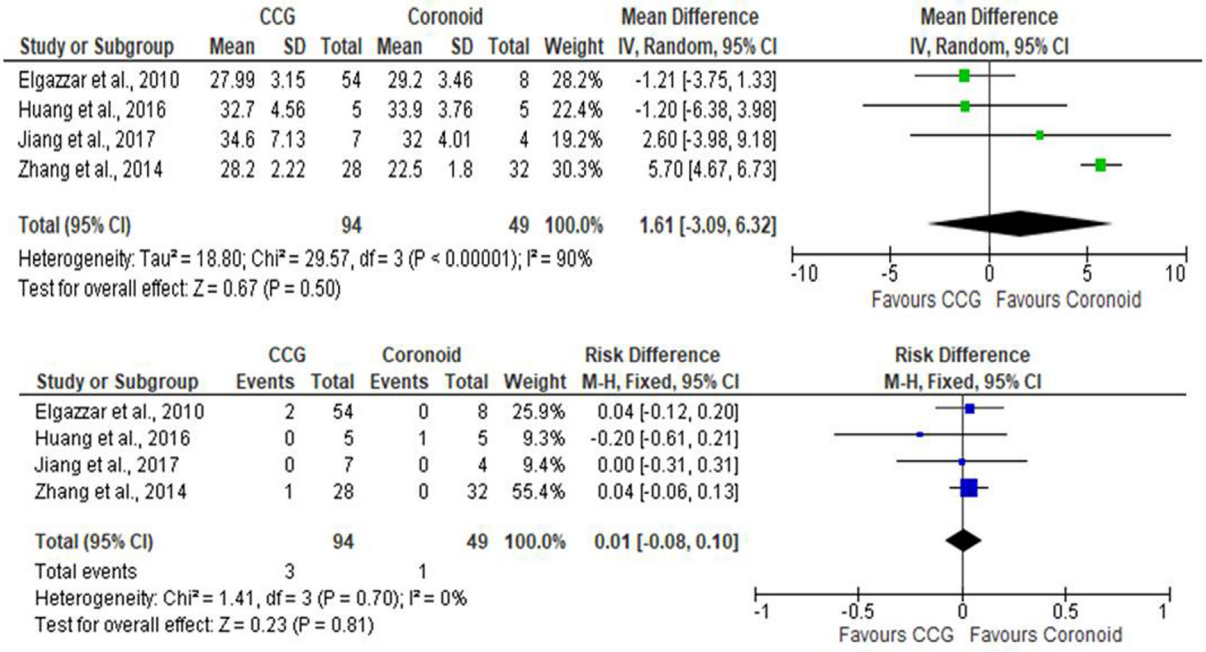

Fig. 2. Comparative postoperative change in maximum incisor opening (δ MIO) and relapse rate in costochondral grafts versus coronoid grafts.

for reconstruction of TMJ. These included CCG (n = 381/700; 54.43%), coronoid (n = 162/700; 23.14%), SCG (n = 69/700, 9.86%), metatarsal (n = 10/700, 1.43%), auricular (n = 17/700, 2.43%), iliac crest (n = 37/700, 5.29%) and remnant condylar mass grafts (n = 11/700, 1.57%).

Quantitative synthesis

CCG versus coronoid grafts

A total of 4 studies[7,9–11] with 143 subjects compared CCG (n = 94) and coronoid grafts (n = 49).

Postoperative change in MIO, δ MIO (Fig. 2)

Standardised mean difference amongst CCG and coronoid grafts was 1.61 mm (95% CI = -3.09 to 6.32 mm); p = 0.50.

Relapse rate (Fig. 2)

A statistically insignificant risk difference of 0.01 (95% CI = -0.08 to -0.10) was found between CCG and coronoid (p= 0.81).

Postoperative change in MIO in different types of autogenous grafts (δ MIO) (Appendix 4, Fig. 3)

A total of 18 studies[7–12,15–26] (n= 268) evaluated δ MIO for CCG (Fig. 3). The pooled mean difference in δ MIO was 27.21 mm (95% CI = 26.87 to 27.55 mm). Data from 8 studies (n=142) on coronoid grafts showed pooled mean difference in δ MIO was 30.47 mm (95% CI = 29.96 to30.99 mm). A total of 5 studies (n=69) analysed SCG and pooled mean difference in δ MIO was 29.67 mm (95% CI = 29.09 to 30.25 mm). Only 2 studies (n=37) reported MIO for iliac crest grafts and pooled mean difference in δ MIO was 31.38 mm (95% CI = 30.63 to 32.12 mm).

Relapse rate (Appendix 4, Fig. 4)

Pooled relapse rate for CCG grafts was 8.130%, n = 34/381 (95% CI = 4.646 to 12.478) (Fig. 4). For coronoid grafts, pooled relapse rate was 2.983%, n = 3/612 (95% CI = 0.994 to 6.757%). For SCG, pooled relapse rate was 8.218%, n = 5/69 (95% CI = 2.066 to 17.932%). Only 2 studies reported relapse rate for iliac crest grafts for reconstruction and pooled relapse rate was 5.649%, n = 2/37 (95% CI= 0.0631 to 19.299). The pooled relapse rate for auricular grafts was 8.301%, n = 1/17 (95% CI = 0.669 to 30.233).

Complications (Table 1)

The data for complications were available for 426/700 subjects only. A total of 133 complications (31.22%), excluding relapse, were reported for 426 subjects. The maximum rate of complications was reported for coronoid grafts, for example, 55/102 (53.92%). For coronoid grafts, the most common complication was graft resorption and was seen in 37/102 subjects. Another highly common complication was temporary nerve paresis in 37/426 (8.69%) subjects. Donor site morbidity was reported for CCG grafts (6/251, 2.34%) and SCG grafts (4/46, 8.70%). All 4 cases of donor site morbidity for SCG grafts were due to clavicle fracture.

Growth rate (Table 2)

Growth rate was reported in only 7 studies[12,18–19,23–24,27–28] with 136 subjects. The follow-up period in these studies ranged from 12-204 months. Data analysis revealed that 76/136 (55.89%) subjects had optimal growth, while 42/136 (30.89%) and 18/136 (13.24%) subjects showed overgrowth and undergrowth, respectively.

Publication bias (Appendix 4)

The publication bias was assessed by constructing Beggs' Funnel plots for all the outcomes; however, in all of the plots except for two plots, the number of studies were <10. This might have caused low sensitivity in analysing the publication bias. The plots for CCG included >10 studies and for both of these plots, publication bias could not be detected because all the studies lied within the funnel or were bilaterally symmetrical outside the funnel thereby verifying the robustness of our results.

Discussion

The present systematic review aimed to compare the clinical outcomes, such as δMIO after 12 months between a variety of autogenous grafts used for reconstruction of TMJ amongst subjects with TMJ ankylosis. Further, the present systematic

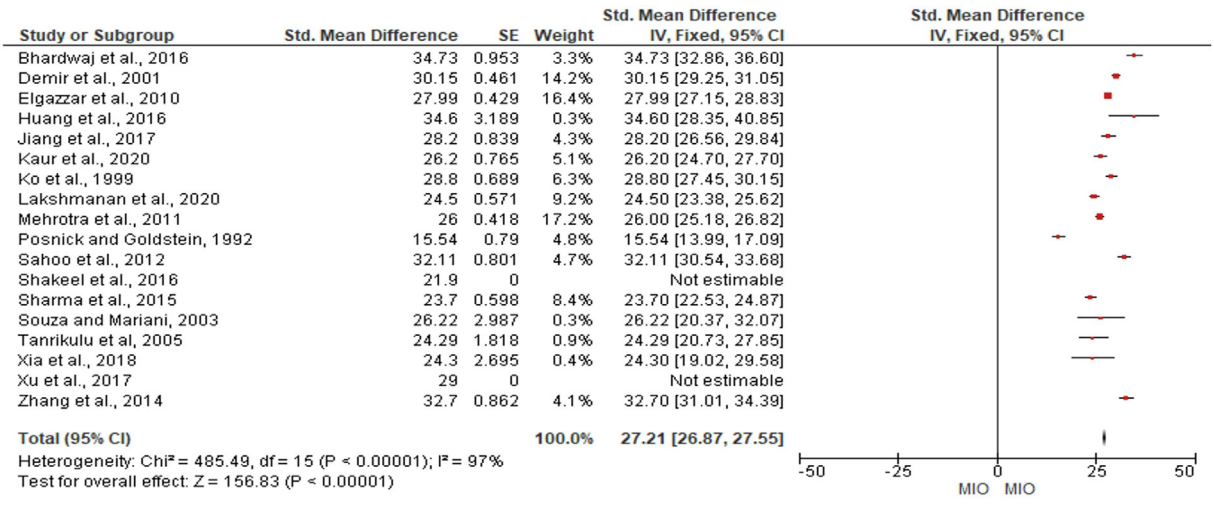

Fig. 3. Postoperative change in maximum incisor opening (δ MIO) in costochondral grafts.

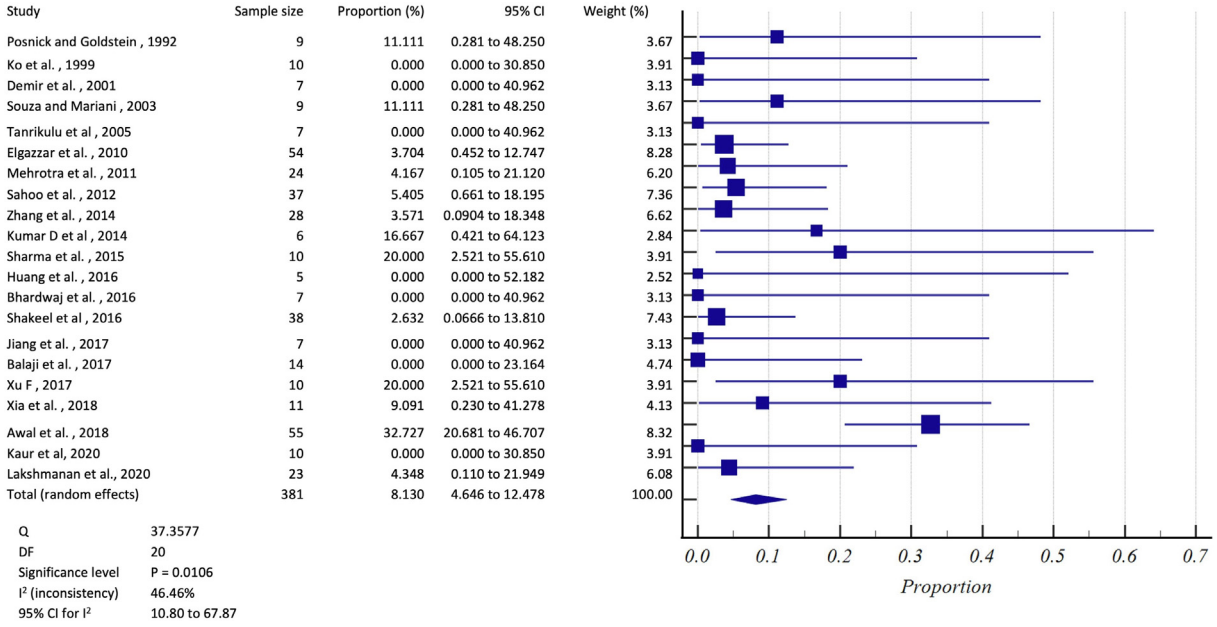

Fig. 4. Relapse rate in costochondral grafts.

review also attempted to pool data on recurrence rates, types and rates of complications, and growth potential of various autogenous grafts. The data were pooled from 35 eligible studies (n = 700)

None of the previously published meta-analyses[2–4] on the surgical management of TMJ ankylosis compared clinical outcomes for different types of autogenous grafts.

The reconstructive arthroplasty in TMJ ankylosis is challenging and this is reflective in the range of choices of autogenous grafts employed by oral and maxillofacial surgeons.[5] Nearly every bone in the human body, such as coronoid process graft, auricular graft, resected ankylotic mass, posterior border of ramus, remnant condyle, iliac bone, SCG, fibula, and metatarsal, has been employed as an autogenous reconstructive option for the regeneration of functional joint. Despite challenges, autogenous grafts remain the preferred treatment option for most surgeons. Amongst these, the most widely used treatment option is CCG, and in the present systematic review, it was employed in 21/35 studies in 348 subjects.

The challenge in conducting a meta-analysis on TMJ reconstruction is the unavailability of RCTs which are considered the gold standard of evidence. In the present meta-analysis, most of the included studies were single-arm interventional studies (both retrospective and prospective) and only 6 of the included studies were parallel-arm interventional studies. Although CCG and coronoid are different types of grafts, a comparative analysis was possible for these two types of grafts, and data were pooled from 4 studies where direct comparisons were made between CCG and coronoid grafts. Both of the grafts performed similarly in terms of rates of re-ankylosis and postoperative MIO. However, the strength of evidence was low as included studies were not RCTs.

The pooled mean MIO for all types of grafts ranged from 27.21 mm to 31.38 mm, which is within a clinically acceptable range. These findings seem reliable because they are in line with published meta-analyses.[2–4] Even though comparative analysis was not possible because of reasons stated earlier, the most successful grafts were coronoid grafts with the least relapse rate of 2.98% (95% CI = 0.99 to 6.76). For the rest of the analysed grafts, such as CCG, auricular, SCG and iliac crest grafts, the pooled relapse rate was ≈8%.

Amongst the commonly employed autogenous grafts, CCG has been the most popular option and it was also obvious from the findings of the present meta-analysis where CCG was employed in 381/700 (54.43%) subjects. Nevertheless, there have been apprehensions regarding its higher relapse rate, donor site complications and erratic growth.[29–30]

For CCG, complications were reported for 251/381 subjects and the overall incidence of complications was 63/251(25.1%). However, serious complications such as donor site morbidity had low incidence (6/251; 2.4%) and included pleural tears (3/251; 1.2%), pneumothorax (2/251; 0.8%) and prolonged postoperative pain (1/251; 0.4%).

Further, the most undesirable sequel of using CCG is its undesirable growth pattern, especially in children (optimal growth, undergrowth, or overgrowth)[29–30] which may require additional surgical intervention to counter the effects of overgrowth. In the present meta-analysis, growth assessment was reported in only 7 studies (n=136) over a follow-up period of 12-204 months. The analysis revealed overgrowth in 30.89% of subjects while optimal growth was reported in 55.89% of subjects. Kumar et al[29] reported data from 3 published case series and reported optimum growth in 50% of subjects. Although Kumar et al[29] included case series with ≥5 years of follow up period only, the findings are consistent with the present meta-analysis. Yang et al[30]

Table 1
Observed complications in various types of grafts. Data are No. (%).

Type of Graft	Number of subjects	Total complications	Infection	Donor site morbidity	Graft fracture	Prolonged postoperative pain	Permanent nerve damage/paresis	Temporary nerve damage/paresis	Graft resorption	Open bite	Mandibular deviation
CCG (n = 251)	251	63 (25.1)	6	6	0	5	0	18	0	1	27
Coronoid (n = 102)	102	55 (53.92)	0	0	0	0	0	14	37	4	0
SCG (n = 46)	46	10 (21.74)	6	4	0	0	0	0	0	0	0
Auricular (n = 17)	17	2 (11.76)	0	0	0	0	0	2	0	0	0
Meta-tarsal (n = 10)	10	3 (30)	0	0	0	0	0	3	0	0	0
Total	426	133 (31.22)	12	10	0	5	0	37	37	5	27

Abbreviations: CCG = Costochondral grafts, NRCT = non-randomised clinical trial, RCT = Randomised controlled trial.
Retro= retrospective, SCG = sternoclavicular grafts.

pooled data from 30 published reports with 68 cases of overgrowth where14/68 subjects were >18 years of age and this observation highlights the inherent growth potential of CCG.

The second most extensively reported graft was coronoid graft which was employed for TMJ reconstruction in 162/700 (23.14%) subjects. Its cortical nature makes it suitable to withstand heavy forces compared to CCG and this is reflected in lower rates of ankylosis in coronoid grafts (2.98%) versus ≈8% in other types of grafts. Although a high incidence of graft resorption was reported in 37/102 (36.72%) subjects, the untoward sequelae of this effect, such as occlusal discrepancies, were not reported.

Further, SCG was the third most commonly employed graft in the present meta-analysis (n = 69/700; 9.86%). The most feared complication of SCG is donor site morbidity, such as clavicle fracture, brachial plexus damage, or damage to great vessels.[5] In the present meta-analysis, clavicle fracture was reported in 4/46 (8.7%) subjects, while the rest of the complications were not reported. Although the relapse rate for SCG was comparable to CCG, donor site morbidity was higher.

Two studies[8,31] reported using iliac crest grafts for TMJ reconstruction and results were favourable with less re-ankylosis (n = 2/37; 5.65%) and no untoward complications. However, the data cannot be directly compared due to smaller study populations (n = 37) for iliac crest graft in the present meta-analysis.

Another less commonly reported graft is auricular cartilage graft which seems an attractive option because it is a readily available source of autogenous graft in proximity to the TMJ and easy to harvest. In the present meta-analysis, 2 studies[32–33] reported auricular grafts and the relapse rate was comparable to other grafts (n = 1/17; 8.3%). The auricular graft lacks bulk and so it offers more of interposition than reconstruction arthroplasty.

Other viable graft options include metatarsophalangeal (MTP) grafts, resected ankylotic mass and posterior border of the ramus. These grafts are not very popular and this trend is visible in the results of the present meta-analysis where MTP grafts and resected ankylotic mass were employed in 1.43% (10/700) and 1.57% (11/700) of subjects only.[34,12] Transferring MTP to TMJ is a complex procedure and so it is not the first choice for TMJ ankylosis. The resected ankylotic mass may also seem a plausible option because of its proximity to the TMJ, ready availability and no need for a second operating site for graft harvest. It comprises dense cortical bone which is amenable to fixation using rigid microplates. However, there is a dearth of data on this technique to warrant long term success.

Nonetheless, there are several deficits in the present meta-analysis. Only a single RCT[17] could be included and the rest of the data were pooled from retrospective/ prospective non-randomised controlled trials. Further, there was lack of comparative trials and the data extraction was done from single arm studies mostly. The overall success of TMJ is based on pain, laterotrusive/protrusive movements, malocclusion, mandibular deviation, facial asymmetry, and overall quality

Table 2
Growth discrepancies in costochondral grafts.

Author, year and reference	Number of subjects	Optimal growth	Overgrowth	Undergrowth
Ko et al, 1999[18]	10	3	7	0
Souza and Mariani, 2003[24]	9	7	2	0
Sharma et al, 2015[23]	10	10	0	0
Balaji et al, 2017[27]	14	2	9	3
Xia et al, 2018[12]	11	11	0	0
Awal et al, 2018[28]	55	42	9	4
Lakshmanan et al, 2020[19]	27	1	15	11
Total	136	76	42	18

of life. However, the data on these parameters were partially reported in the included studies. Additionally, the success of the procedure is dependent on the surgeon's skills, the severity of disease, age at the time of onset of disease, duration of ankylosis, and physiotherapy. However, the partial reporting in the included studies precluded us from analysing the effect of these confounding factors. Next, the analysis of data as per age stratification was also not feasible as most of the studies reported on mixed-age groups.

Conducting RCTs is challenging owing to the availability of a lesser number of subjects as TMJ ankylosis has a low incidence, surgeons have their individual preferences and expertise and logistic/monetary restrictions for ensuring follow up. The multicentre trial can be a solution to overcome these limitations which may allow enrolling subjects in larger numbers enabling control of confounding variables.

Conclusion

The most favoured autogenous grafts were CCG and coronoid grafts. The reported outcomes, such as MIO and recurrence rates were comparable for all types of grafts except coronoid grafts where the lowest recurrence rates were observed, which may be due to the cortical nature of the graft. The CCG graft showed optimal growth in 55% of subjects. However, as the data were pooled from single-arm studies, the strength of the evidence is low and readers' discretion is advised in interpreting the results.

Ethics statement/confirmation of patients' permission

Ethics approval not applicable. The study did not involve any human participants.

Conflict of interest

We have no conflicts of interest.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bjoms.2022.05.012.

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