



A Comprehensive Evaluation of Alloplastic Total Joint Replacement Versus Costochondral Graft for Temporomandibular Joint (TMJ) Reconstruction: A Review

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ABSTRACT

Temporomandibular joint (TMJ) disorders pose a complex challenge in oral and maxillofacial surgery, necessitating effective surgical interventions for successful management. Alloplastic total joint replacement and costochondral grafting are pivotal techniques in TMJ reconstruction, addressing the intricate nature of available treatment options. This comprehensive review conducts a comparative analysis, reviewing existing literature, emphasizing indications, surgical techniques, outcomes, complications, and cost-effectiveness. Alloplastic joint replacement utilizes artificial materials for TMJ restoration, while costochondral grafting involves autogenous rib grafts. Both approaches exhibit positive clinical outcomes, with unique advantages and limitations. The analysis encompasses functional outcomes, aesthetic considerations, complication rates, and cost-effectiveness, providing valuable insights for clinical decision-making.

Keywords: Temporomandibular joint, TMJ disorders, alloplastic total joint replacement, costochondral graft, surgical techniques, outcomes, complications, cost-effectiveness, literature review.

INTRODUCTION

Temporomandibular joint (TMJ) disorders present a complex challenge in the field of oral and maxillofacial surgery, demanding effective surgical interventions for successful management. Alloplastic total joint replacement and costochondral grafting have emerged as crucial techniques in TMJ reconstruction, highlighting the intricate nature of available treatment options.¹ The prevalence of TMJ disorders underscores the critical need to comprehensively understand and evaluate these surgical approaches to enhance patient outcomes. Alloplastic total joint replacement entails the use of artificial materials to restore TMJ function, while costochondral grafting involves utilizing autogenous grafts from the patient's rib to reconstruct the joint. In cases of end-stage TMJ pathology leading to anatomical changes and restricted jaw function, total joint replacement becomes necessary.² However, it's essential to acknowledge that the restored joint may not fully regain its pre-morbid, fully functional condition due to the complex functional relationship of TMJ with local anatomy and masticatory muscles, coupled with the technical challenges of implanting a replacement. Indications for TMJ replacement encompass joint ankylosis, rheumatoid arthritis, neoplastic disease, severe osteoarthritis, post-traumatic disorders, and congenital diseases or syndromes.³ The primary objectives of the procedure include the restoration of mandibular function and form, reduction of patient disability, and prevention of disease progression. A variety of reconstruction methods exist, offering autogenous grafts and alloplastic techniques as viable options. Among autogenous techniques, the costochondral graft is widely accepted, providing biological compatibility, workability, functional adaptability, and minimal additional detriment to the patient. Its growth potential makes it particularly suitable for children. However, potential complications with the costochondral graft include fracture, increased ankylosis, donor site morbidity, and the unpredictable growth tendency of the graft.⁴ Customized alloplastic materials offer several advantages over costochondral grafts. TMJ Concepts, among the alloplastic materials, demonstrates reliable and predictable results. Unlike costochondral grafts, TMJ Concepts eliminates the risk of donor site morbidity. The ability to manufacture TMJ Concepts individually negates the need for bending or modification during surgery, resulting in reduced surgical time compared to costochondral grafts. Nevertheless, TMJ Concepts lacks growth capability, limiting its applications in growing patients.⁵ This review aims to provide an extensive comparative analysis of these approaches, focusing on their respective indications, surgical methodologies, outcomes, complications, and cost-effectiveness.

MATERIALS AND METHODS

A comprehensive review of the literature was carried out to perform a comparative analysis between Alloplastic Total Joint Replacement and Costochondral Graft in Temporomandibular Joint (TMJ) Reconstruction. The research, led by junior residents from Thai Moogambigai Dental College and Hospital in Chennai, was approved by the Department of Oral and Maxillofacial Surgery at the institution. A systematic exploration of established electronic databases, including PubMed, MEDLINE, and SciSpaceLibrary, was conducted. Strategic use of keywords such as "Alloplastic Total Joint Replacement," "Costochondral Graft," and "Temporomandibular Joint Reconstruction" was employed to ensure the inclusion of pertinent articles. The search spanned studies published up to the present date. Inclusion criteria for this comparative analysis specified a focus on either Alloplastic Total Joint Replacement or Costochondral Graft in TMJ Reconstruction. Human-based studies presenting quantitative or qualitative data on outcomes related to either technique were considered, while exclusion criteria were applied to non-English studies, those involving animal subjects, and those not meeting the specified focus criteria. Systematically collecting information from selected articles, including study design, patient characteristics, surgical techniques, and outcomes, constituted the data extraction process. A thorough synthesis of the extracted data was undertaken to draw meaningful comparisons between Alloplastic Total Joint Replacement and Costochondral Graft in TMJ Reconstruction. The review process adhered to ethical standards, and approval was obtained from the Ethics Committee of the college.

ALLOPLASTIC TOTAL JOINT REPLACEMENT

Alloplastic total joint replacement is a surgical intervention indicated for various conditions affecting the temporomandibular joint (TMJ), including joint ankylosis, rheumatoid arthritis, neoplastic disease, severe osteoarthritis, post-traumatic disorders, and congenital diseases or syndromes. Patient selection involves a comprehensive evaluation, considering the severity of TMJ pathology, the patient's overall health, and potential benefits compared to other treatment options. The surgical technique includes exposure, joint removal, placement of alloplastic implants (commonly made of biocompatible materials like titanium), secure fixation, and closure. TMJ Concepts provides customized implants tailored to the patient's anatomy.⁵ Clinical outcomes and long-term results of alloplastic joint replacement have generally been positive, with patients experiencing improved jaw function, reduced pain, and enhanced quality of life. Long-term studies and follow-ups demonstrate the longevity and success of replacement joints, provided patients adhere to postoperative care guidelines, are appropriately selected, and maintain overall health. Complications associated with alloplastic joint replacement include the risk of infection, implant failure over time leading to potential revision surgery, malocclusion resulting in bite issues, and, in rare instances, allergic reactions to implant materials. Regular monitoring and follow-up appointments are essential for early identification and intervention in case of complications. Patient education on potential risks and strict adherence to postoperative care guidelines contribute to minimizing complications associated with alloplastic joint replacement. In the management of severe and debilitating end-stage joint disease, alloplastic total joint reconstruction is acknowledged as a biomechanical option rather than a biological one. Alloplastic joint prostheses have become indispensable in modern reconstructive orthopaedic surgery, revolutionized by Sir John Charnley's successful low-friction total joint replacement device for the hip in the 1960s. While orthopaedic joint replacement devices have demonstrated survival rates exceeding 90% after 10 years, temporomandibular joint (TMJ) reconstruction poses unique challenges due to the joint's functional intricacies and anatomical relationships with surrounding structures. Before 1980, alloplastic materials were used for hemiarthroplasty/partial joint replacement in TMJ cases involving ankylosis, tumor surgery, trauma, or severe joint pathology, often resulting in single case reports with limited follow-up. However, in 1982, the Proplast-Teflon Interpositional TMJ Implant and a total TMJ replacement implant system faced FDA withdrawal due to foreign body giant cell reactions. Subsequent attempts to reconstruct damaged joints failed, emphasizing the need for improved TMJ devices.⁶ The advent of computer-assisted design/manufacture (CAD/CAM) in 1989 marked a pivotal moment, with the development of the first custom TMJ reconstruction prosthesis. This aimed to address anatomical discrepancies and challenges associated with stock device components. In the following years, Zimmer Biomet conducted clinical trials leading to FDA approval for stock and custom TMJ replacement systems. Studies demonstrated safety, effectiveness, and improved quality of life for patients with end-stage TMJ disease.⁷ Despite the success of TMJR devices, concerns over material biocompatibility persist. Cobalt-chromium-molybdenum (CoCrMo) and titanium (Ti6AlV4) are commonly used alloys, but issues like nickel hypersensitivity and concerns over aluminum/vanadium content have prompted research into new alloys. Ultrahigh molecular weight polyethylene (UHMWPE) remains a standard bearing surface material, while alternate surfaces like ceramics and diamond-like carbon are being explored. Recent advancements involve the increased use of additive manufacturing (AM) in TMJR device production, addressing concerns over porosity and manufacturing costs. However, challenges exist in understanding the fundamental relationships in metal 3D printing. Future developments aim at improving TMJR devices with active functionalities. Biochemical surface modifications, passive devices with *in vivo* biomechanical monitoring, and active smart implants incorporating therapeutic actuation and sensing systems are envisioned. Research efforts include coating components with human monoclonal antibodies to prevent biofilm infections and using acoustic emission detection for early micromotion sensing.⁸

COSTOCHONDRAL GRAFT

Costochondral grafting is a surgical intervention employed in the management of temporomandibular joint (TMJ) disorders, particularly when conventional treatments prove inadequate. Indications for this procedure include TMJ ankylosis, severe osteoarthritis, traumatic injuries, developmental abnormalities, and cases requiring reconstruction due to congenital diseases or syndromes.⁸ Patient selection criteria involve a thorough assessment of the extent of TMJ pathology, overall health, and the appropriateness of costochondral grafting in comparison to alternative interventions. The surgical technique for costochondral grafting encompasses specific steps to ensure optimal outcomes. An incision is made to access the TMJ region, and a costochondral graft is harvested from the patient's rib, typically the sixth or seventh rib, along with a cartilage cap to mimic the condyle. The damaged

TMJ components are then removed, making space for the graft. Special attention is given to minimizing donor site morbidity, and the graft is securely fixed in place, aligning the cartilage cap to restore joint functionality. The incision is closed, initiating the postoperative care phase.⁹ Clinical outcomes of costochondral grafting have generally been positive, with patients experiencing improved TMJ function and reduced pain. Long-term studies indicate the durability of the grafts, particularly when proper surgical techniques are employed, and patients adhere to postoperative care instructions. The restoration of mandibular form and function contributes to an enhanced quality of life over the long term. Complications associated with costochondral grafting, while infrequent, may include graft fracture, ankylosis, donor site morbidity at the rib, and unpredictable growth potential in pediatric patients. Regular follow-up and monitoring are imperative to promptly identify and address any complications. Patient education on potential risks and strict adherence to postoperative care guidelines play a crucial role in minimizing complications associated with costochondral grafting.¹⁰

REVIEW OF LITERATURE

In a retrospective study conducted by Saeed and Kent, involving 57 patients and 76 grafts, it was emphasized that Costochondral Graft (CCG) reconstruction of the Temporomandibular Joint (TMJ) can yield excellent results.¹⁰ Similarly, Villanueva-Alcojol et al. in their retrospective study with 13 patients and 17 grafts concluded that utilizing CCG for mandibular condyle reconstruction, particularly employing the green-stick fracture technique, offers optimal outcomes in the surgical treatment of temporomandibular pathology.¹¹ Medra, in another retrospective analysis of 55 patients and 85 grafts, reported good remodeling in 59% of cases, with 9% experiencing reankylosis, 25% graft resorption, and 4% graft overgrowth.¹² Furthermore, Vasconcelos et al., in a retrospective study involving 3 patients and 4 grafts (arthroplasty in 10 patients, Alloplastic reconstruction in 2 patients), suggested that both autogenous and alloplastic grafts, as well as gap arthroplasty, are efficient for ankylosis treatment in terms of postoperative maximal incisal opening, recurrence, and joint function.¹³ El-Sayed, in a retrospective study involving 12 patients and 14 grafts, recommended the routine use of a modified approach for costochondral grafting in TMJ reconstruction.¹⁴ Tanrikulu et al., in a retrospective study with 7 patients and 9 grafts (gap arthroplasty in 8 patients, soft tissue interpositional arthroplasty in 9 patients), highlighted that the effect of interpositional arthroplasty on postoperative maximal interincisal mouth opening surpassed that achieved using other methods.¹⁵ Additionally, He et al., in a retrospective study with 33 grafts (20 CCG only, 11 CCG with TMF, 2 CCG with MMF), indicated that CCG with TMF yields favorable outcomes for ankylosis.¹⁶ Moving to studies related to Total Joint Prostheses, Wolford et al., in a retrospective analysis of 38 patients and 69 joints, asserted that the TMJ Concepts/Techmedica total joint prosthesis exhibits long-term efficacy.¹⁷ Murdoch et al., in a retrospective study with 42 patients and 63 joints, suggested that the TMJ Concepts patient-fitted system provides improved long-term results.¹⁸ Sidebottom and Gruber, in a prospective study involving 74 patients and 103 joints, provided further evidence supporting the efficacy and safety of total alloplastic TMJ reconstruction.¹⁹ Mercuri et al., in a retrospective analysis of 58 patients and 97 joints, concluded that the CAD/CAM patient-fitted total TMJ reconstruction system proves to be a safe and effective long-term management modality. Similarly, in another retrospective study with 61 patients and 102 joints, Mercuri et al. reiterated that the patient-fitted total TMJ reconstruction system remains a safe, effective, and reliable long-term solution for the specific patient population studied.²⁰ Lastly, Jones, in a retrospective analysis involving 2 patients and 3 joints (Biomet in 5 patients), found that alloplastic joint replacements were aesthetically pleasing, but long-term evaluation is deemed necessary.²¹ Overall, these studies collectively contribute to the understanding of the advantages, limitations, and potential complications associated with different TMJ reconstruction techniques. The variety of approaches discussed, from CCG to Total Joint Prostheses, provides clinicians with a nuanced perspective, allowing them to tailor their choices based on individual patient characteristics and specific clinical scenarios. Both methodologies have demonstrated effectiveness and find application across diverse patient demographics.

CONCLUSION

In conclusion, both Alloplastic Total Joint Replacement and Costochondral Graft exhibit proven efficacy in managing TMJ disorders. Costochondral Grafting demonstrates versatility and excellent outcomes, while Alloplastic Total Joint Replacement, particularly with systems like TMJ Concepts, offers long-term reliability. The choice between the two techniques depends on factors such as the specific pathology and patient characteristics. Continuous evaluation and advancements in technology further contribute to the evolving landscape of TMJ reconstruction.

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