

Systematic Review TMJ Disorders

Alloplastic temporomandibular joint replacement systems: a systematic review of their history

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Abstract. This systematic review provides an overview of the historical evolution of the prosthetic temporomandibular joint and addresses the challenges and complications faced by engineers and surgeons, in an effort to shed light on why only a few systems remain available. A better understanding of the history of temporomandibular joint prostheses might also provide insights into the origin of the negative public opinion of the prosthesis, which is based on outdated information. A computerized search using the PubMed Central, ScienceDirect, Wiley Online, Ovid, and Cochrane Library databases was performed following the PRISMA guidelines. Out of 7122 articles identified, 41 met the inclusion criteria for this systematic review. Although several historical reviews have been published previously, none has covered such an extensive time period or has described all designs. Furthermore, besides providing a historical overview, this review discusses the rationale behind the evolution in design and biomaterials, which have largely contributed to the outcomes of the prosthetic systems.

Key words: temporomandibular joint; prostheses and implants; literature review; history.

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The temporomandibular joint (TMJ) is subjected to more cyclic loading and unloading than any other joint in the body. As a result, temporomandibular disorders (TMDs) are far from rare¹. Early data from 1990 indicated a prevalence of TMD of about 12% in the general population, but the more recent literature has provided more conservative estimates¹. A 2008 study by the National Health Interview Survey concluded that up to 5% of all Americans deal with TMD-related pain²,

and a study conducted by Janal et al. in 2008 noted an even higher prevalence, reporting that up to 10% of all female patients examined had a TMD³. The literature concurs, however, that a significantly higher proportion of TMDs manifest in women than in men (3:1 ratio). Furthermore, symptoms tend to first present between the ages of 20 and 40 years, and tend to lessen as the patient ages^{1–3}.

Despite the high prevalence of TMDs, the use of a surgical approach is only

rarely needed. As such, the pre-requisites for TMJ replacement surgery are a combination of positive radiological imaging confirming a pathology and structural changes within the TMJ, a significant history of pain and dysfunction, and failure of previous conservative and surgical treatments. The current indications for TMJ replacement surgery as reported by the American Association of Oral and Maxillofacial Surgeons (AAOMS)⁴ and in the National Institute for Health and

2 *De Meurechy and Mommaerts***Table 1.** Indications for TMJ replacement surgery^{2,4,5}.

Care Excellence guidelines⁵ are listed in [Table 1](#).

At first, joint surgery consisted largely of surgical excision, which was mainly performed for severely damaged joints, with the first documented hemi- and total mandibular resections dating from the early 19th century^{6,7}. The initial placement of alloplastic material as a treatment for TMD dates back to the mid-19th century. The surgical procedures performed in this first century of TMJ intervention can largely be classified as ‘experimental’, with concepts rarely gaining attention. By the mid-20th century, however, many different types of TMJ surgery and TMJ replacements were being explored, ranging from disc prostheses to total joint replacement (TJR). Despite promising short-term results, the long-term results of these systems often proved disappointing, and in some cases resulted in serious inflammation with destruction of the surrounding tissues. As a result, this era of development soon tapered off. Although many different systems were conceived, only two main manufacturers of serial US Food and Drug Administration (FDA)-approved total TMJ prostheses remain globally.

Table 2. Interpositional materials and fossa prostheses^{6,12,13,15–19,21,24–26}.

Material	Surgeon	Year of introduction
Wood	Carnochan	1840
Gold	Rosner	1889
Gold-coated aluminium plate	Orlow	1903
Ivory	Partsch	1932
Gold foil	Risdon	1934
Metallic plate	Risdon	1934
Tantalum	Eggers	1946
Tantalum	Goodsell	1947
Stainless steel	Smith and Robinson	1957
Stainless steel	Robinson	1960
Co–Cr	Christensen	1963
Tantalum	Hellinger	1964
Co–Cr	Morgan	1965
Silastic	Robinson	1968
Silastic	Kriens	1973
Proplast-Teflon	Vitek	1976

Table 3. Materials and TMJ condylar prostheses^{6,13,20,21,26–35}.

Material	Surgeon	Year of introduction
Rubber ^a	Martin	1878
Rubber ^a	Schöder	1901
Ivory	Gluck	1890
Tin ^a	Fritzsche	1901
Ivory	König	1908
Ivory	Sudeck	1909
Glass ^a	Partsch	1917
Co–Cr with acrylic condyle	Hahn	1964
Co–Cr with condylar Teflon coating	Kent	1972
Titanium	Spiessl	1976
Co–Cr with PMMA cement	Silver	1977
Titanium	Raveh	1982
Steel with polyethylene cap	Flot	1984
Titanium with Al ₂ O ₃ cap		1987

^aNote: these prostheses were immediate prostheses and not implantation devices.

An overview of the different prosthetic systems is provided in [Tables 2–4](#).

Materials and methods

Information about the history and evolution of the TMJ prosthesis over time was gathered by performing a computerized literature search using several databases. This search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines⁸. The following databases were used: PubMed Central, Elsevier ScienceDirect Complete, Wiley Online Library Journals, Ovid Lippincott Williams & Wilkins, and Cochrane Library Plus. The following search terms were used: (“TMJ” OR “temporomandibular joint”) AND (“replacement” OR “prosthesis”) AND (“history” OR “evolution” OR “advancement”). The combination in which these terms were used varied slightly depending on the database, although the search terms themselves remained unchanged.

To assess the methodological soundness of each article, a quality evaluation was performed using the 2011 Oxford Centre for Evidence-Based Medicine Levels of Evidence (OCEBM LOE) recommendations⁹. Quality was categorized from level I to level V. Articles written in a language other than English, Dutch, German, or French were not included.

The initial search returned 7122 published articles. Subsequently, the number of articles was reduced by removing all duplicates, after which the titles and abstracts of the remaining articles were screened on their content and relevance to the search. In the case of any uncertainty, a second reviewer was called on to evaluate the title or abstract as well. This process led to the exclusion of 7036 articles. After examining the final 86 articles and confirming the quality of these studies, excluding any level V studies, 20 articles were included in the systematic review. An additional 21 articles were identified by manually searching the reference lists of the included articles. These articles mainly concerned the original articles for the different prostheses reported over time. The search results are summarized in a PRISMA flow chart in [Fig. 1](#). Considering the need for historical accuracy, a few original articles concerning early implant systems could not be excluded for obvious reasons, even when they attained only level V for quality; these studies are marked ‘H’.

Results

TMJ fossa–eminence prostheses and condylar prostheses used separately

Interpositioning materials and fossa prostheses (Table 2)

John Carnochan¹⁰ (H) was a pioneering neurosurgeon who first described the use

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