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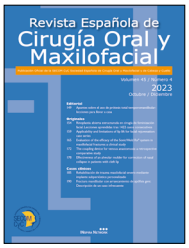

Editorial

Notes on the use of total temporomandibular prosthesis: lessons to take home

Apuntes sobre el uso de prótesis total temporomandibular: lecciones para llevar a casa

Recently (April 11 and 12, 2024), the VII National Conference on Temporomandibular Joint (TMJ) was held at the Real Colegio Seminario de los Padres Agustinos, in Valladolid, this year focusing on Updates and New Technologies in the Prosthetic Reconstruction of TMJ, and with the participation of renowned speakers in joint pathology, especially in prosthetic joint replacement. Throughout the conference, different aspects were addressed, such as the indications for prosthetic reconstruction, infections of joint implants, hypersensitivity reactions to their components, the use of virtual planning and navigation, the treatment of reankylosis, the role that stock prostheses occupy in an increasingly widespread use of custom-made TMJ prostheses, the use of surgical guides in the transfer of what is planned to the operating room, prosthetic reconstruction in tumors jaws that have been treated with or without radiotherapy, alloplastic reconstruction in childhood and adolescence, joint prosthetic reconstruction concomitant to the treatment of dentofacial deformities, and the role of post-surgical physiotherapy.

The **general objectives** of TMJ prosthetic reconstruction are: 1) restore joint morphology; 2) restore the height of the mandibular ramus; 3) increase joint range of motion without pain; 4) correct dentofacial anomalies in conjunction with orthognathic surgery; and 5) prevent the recurrence of some joint diseases, such as juvenile idiopathic arthritis (JIA). The **main indications** are: 1) Recurrent fibrosis or bone ankylosis; 2) inflammatory arthritis involving the TMJ (JIA, ankylopoietic spondylitis, scleroderma); 3) previous graft failure; 4) failure of previous alloplastic joint reconstruction, and 5) loss of jaw height and alteration of occlusion. **Contraindications,** which also have them, are: 1) active infections in or around the implant site; 2) uncontrollable hyperfunction of the masticatory muscles, which would generate overload and loss of the fixation screws; 3) known allergy to any of the components of the materials; and 4) uncontrolled systemic disease.

Likewise, the maxillofacial surgeon must be aware of the potential appearance of **adverse effects, poor results or complications** such as: 1) infection; 2) intra-operative technical difficulties; 3) foreign body gigantocellular reaction to prosthesis components; 4) ear problems, such as inflammation of the external auditory canal (EAC), infection of the middle or inner ear, temporary or permanent hearing loss or tinnitus; and even 5) deleterious effects on the contralateral healthy joint.

Some important messages were highlighted in relation to the **design of the prosthesis,** such as: 1) in most current prosthetic designs, after the placement of the TMJ prosthesis, there is only pure rotational movement, due to disinsertion. of the lateral pterygoid muscle; 2) in the TMJ, the biconcave articular disc allows congruency to be maintained during extensive

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joint movement, and yet the congruence of the TMJ prosthesis ultimately depends on the implant design; 3) if the position of the condyle descends 3-4 mm, and therefore its point of rotation does the same, the use of the unilateral TMJ prosthesis does not overload the healthy contralateral joint. Likewise, **key aspects** were highlighted, such as: 1) total joint replacement of the TMJ is effective in terminal joint disease in the hands of experienced surgeons; 2) virtual pre-surgical planning allows for very precise adaptation of the implant; 3) measures to prevent peri-prosthetic joint infection must be strictly followed; 4) surgical cutting guides allow the exact transfer of what was planned virtually, 5) stock prostheses, unlike custom-made ones, require significant preparation of the bone bed for adaptation; 6) the fossa component must be fixed with at least 4 screws, and the mandibular ramus component with 5 screws; 7) Post-operative active joint physiotherapy is essential for long-term success.

In relation to the two main existing prosthesis systems, "stock" and "custom-made", their **main differences** should be highlighted.

– **Stock prostheses:** 1) provide poor adaptability in patients with altered anatomy; 2) they have a limited potential to allow the performance of antero-inferior mandibular movement; 3) they require extensive experience to deal with variability in adaptation; and 4) due to the lower adaptability to the native bone, they are more prone to material fatigue, micro-movements and eventual prosthetic failure. either.

Its main *advantages* are: 1) flexibility to unexpected surgical findings, since the patient's bone adapts to the prosthesis and not the other way around; 2) immediate availability; and 3) lower economic cost.

– **Custom-made or "custom-made" prostheses:** 1) allow easy adaptation, without the need to alter the bone and less surgical time; 2) facilitates high osseointegration and stability; 3) allow a certain infero-anterior mandibular movement; 4) allow control of screw insertion to avoid damage to the lower dental nerve; 5) allow the reconstruction of post-traumatic defects, secondary to osteomyelitis and oncological receptive; 6) in cases of severe hypoplasia (hemifacial microsomia) the extended fossa and mandibular components allow the replacement of the missing bone; and 7) in simple cases, the prosthesis design with a short mandibular component allows its introduction through a limited retromandibular approach, reducing the potential risk of damage to the mandibular branch of the facial nerve.

Its *main disadvantages* are: 1) less flexibility in the face of "unexpected" surgical findings, since the prosthesis adapts to the bone and not the other way around; 2) high supply time; and 3) high economic cost.

In a meta-analysis by De Mereuchy et al.[1] in which 15 of 1581 identified articles were selected, a significant decrease in pain and a significant increase in oral opening and diet score were observed) for both systems, although no statistically significant differences were found between stock prostheses and custom-made prostheses, this study does not consider the severity of the pathology included in the meta-analysis, which may influence the post-op results, for be a selection bias, since stock prostheses were generally reserved for less complex cases. The use of custom-made prostheses in the most complex patients reduces the risk of injury to the facial nerve and the inferior alveolar nerve, optimizing the positioning of the screws and reducing the size of the approach, and probably reduces the need for second interventions, although this is a fact not yet proven in terms of evidence-based medicine.

Regarding the materials used, most of the types of prostheses available on the market are made of: 1) a medical grade titanium alloy (Ti6Al4V ELI), whose components are: titanium (Ti) 89-91 %, aluminum (Al) 5.5-6.5 %, and vanadium (V) 3.5-4.5 %; and 2) Cobalt (Co)-Chromium (Cr)-Molybdenum (Mo), in proportion: Co 58.9-69.5 %, Cr 27-30 %, and Mo 5-7 %. The mandibular component is made mostly of a Ti alloy, but nitride-coated Ti, pure Ti, alumina-sandblasted grade 23 Ti, Co-Cr-Mo alloy, and poly-ethyl ether ketone (PEEK) are also used. The internal surface of the mandibular component can be treated by plasma sprayed with Ti, to promote adhesion. The condylar head is made of Co-Cr-Mo in most prosthetic designs, although they also exist in Ti alloy, Carbon coated, commercially pure Ti, PEEK and zirconia. The glenoid fossa component is predominantly made of ultra-high molecular weight poly-ethylene (UHMWPE) with or without Ti mesh. Co-Cr-Mo is preferred instead of Ti alloy as the alloy of said mesh bonded to UHMWPE[2]. The Co-Cr-Mo alloy has superior wear resistance, although traces of residual nickel (Ni) (< 1 %) may be responsible for cases of hypersensitivity. In order to alleviate this situation, new Ni-free alloys are being developed, with similar biological and mechanical properties. One of them is made up of Fe18Cr14Mn3.5MoN0.9, a type of stainless steel with high resistance to corrosion, high nitrogen (N) content and no Ni. The Ti alloy (Ti6AlV4) most frequently used alloy in TMJ prostheses, with Al and Va being potentially responsible for hypersensitivity reactions. The incorporation of new elements that minimize this risk is being tested, such as niobium, molybdenum, tantalum, zirconium and tin. The Beta-Ti alloy (TiZrMoFe) has a lower elastic modulus, provides less protection against stress at the implant-bone interface, and its behavior in TMJ joint replacement is unclear. UHMWE is the most common bearing surface material for the fixed or glenoid fossa component, as it allows for optimal wear behavior, durability and biological inertness, so there is less concern about material wear or fracture. Other materials, such as PEEK or diamond-type carbon (Ca), require more studies to ensure their effectiveness and safety in this type of prosthesis[3].

Computer-aided manufacturing includes: 1) additive manufacturing (AM) or 3D printing; and 2) subtractive techniques (computer numerical control, CNC milling), which produces forged components and cast alloys. While CNC milling remains the most frequency used manufacturing procedure, AM is increasingly used to allow an extremely high degree of design freedom, the production of small detailed structures, and the incorporation of lattice or honeycomb structures to promote bone growth or improve mechanical properties. It seems clear that, while subtractive techniques remain the majority manufacturing procedure for custom TMJ prostheses, additive manufacturing is increasingly being used to allow: 1) an extremely high degree of design freedom; 2) produce small detailed structures; 3) incorporate lattice or honeycomb structures to promote bone growth or improve mechanical properties. However, we must take into account that components manufactured with AM have not yet been compared with those produced conventionally in terms of mechanical resistance and clinical results and/or complications in the medium and long term. Regarding manufacturing techniques: 1) wrought components obtain a smaller grain size and therefore a more uniform material, which improves the structure and resistance of the implant; 2) cast alloys obtain a larger grain size and cooling gaps are generated, which generates imperfections and lower resistance; 3) additive manufacturing or 3D printing improves porosity, production speed and reduces costs, although it has a greater propensity for failure due to fracture[3].

Currently, there are 15 countries that manufacture TMJ prostheses and 27 different models[4]. To these we should add a Spanish manufacturing model, developed by the San Juan de Alicante Hospital and the Canary Islands Technological Institute, whose preliminary results were published in our magazine in 2019[5]. If we refer to the Anglo-Saxon literature, of the 27 prosthesis systems, 21 are custom-made and 6 are stock: 1) all systems have a glenoid fossa component and a mandibular ramus component; 2) all but 5 are similar to the two Food and Drug Administration (FDA) approved systems (Stryker-TMJ Concepts and Zimmer-Biomet) (Figures 1 to 3); 3) 12 systems have followed a verification process through preclinical laboratory tests; 4) only the 2 systems approved by the FDA have large clinical series with long-term follow-up. Regarding the fossa component: 21 systems are made of UHMWPE (17 custom-made and 4 stock), 11 of which have a metal alloy mesh interposed between the UHMWPE and the bone, 10 are completely UHMWPE, 5 of metal on metal; and 1 of polymer. Regarding the condylar head: 10 systems are made of Ti alloy, 3 of Cr-Co alloy, 7 of Cr-Co-Mo alloy, 4 of stainless steel, and another 4 of other materials (zirconium, Ti nitride, PEEK). Regarding the mandibular ramus component: 19 systems are made of Ti alloy, 3 of stainless steel, 2 of Cr-Co alloy, 1 of Ti nitride, and 1 of PEEK[4].

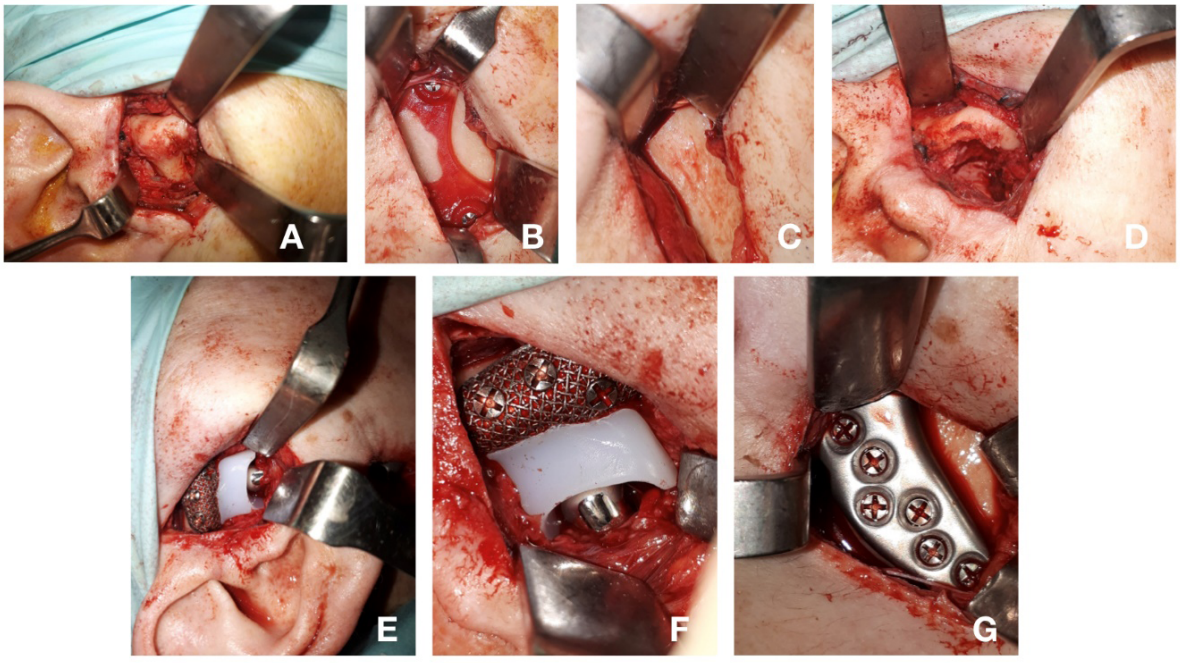

Figure 1. Patient with fibro-osseous ankylosis of the TMJ. A: view of the ankylotic block; B: placement of surgical cutting guide; C: osteotomy at the level of the mandibular ramus; D: view of the defect after removal of the ankylotic block; E: placement of custom-made total TMJ prosthesis (TMJ Concepts system); F: detail of the pit component; G: detail of the mandibular component.

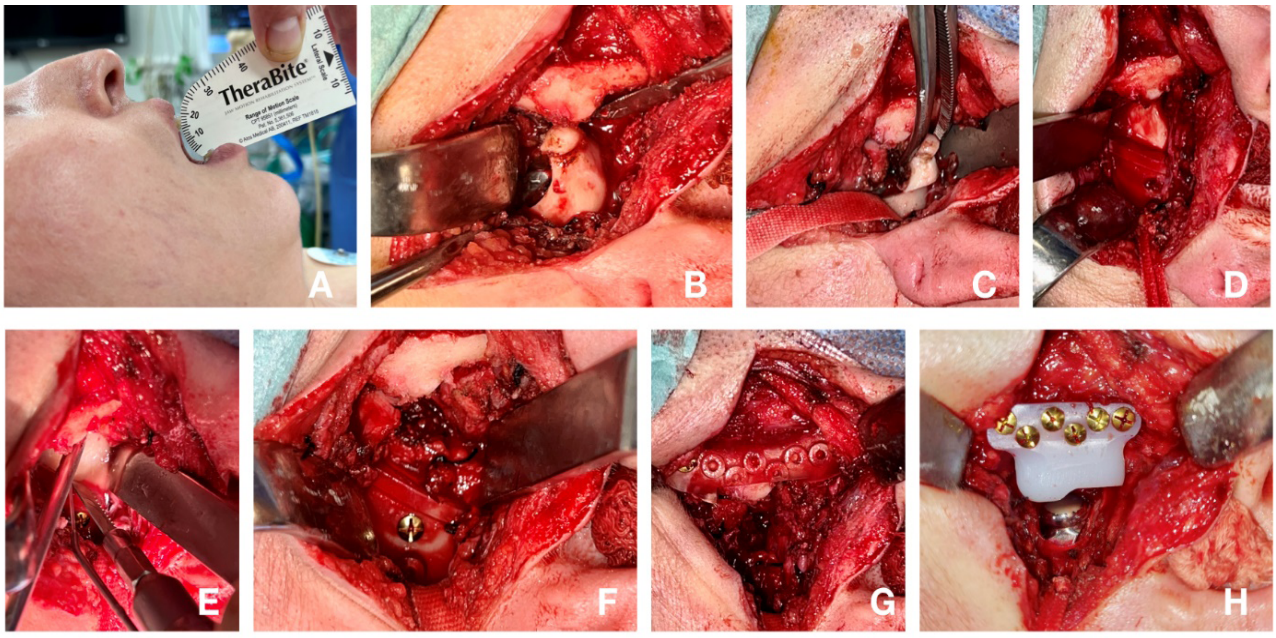

Figure 2. Patient with osteoarthrosis of the TMJ (Wilkes V TMJ pain-dysfunction syndrome). A: severe decrease in maximum oral opening; B: view of the mandibular condyle with signs of osteoarthrosis (osteophyte in the anterior pole); C: removal of the cranial part of the mandibular condyle to create a gap; D: cranial propulsion of the mandibular ramus and placement of the mandibular ramus cutting guide; E: osteotomy following the cutting plane marked by the cutting guide; F: view of the defect after removal of the caudal part of the mandibular condyle; G: placement of the cutting guide at the level of the fossa/eminence; H: placement of custom-made total TMJ prosthesis (Walter Lorenz/Biomet system).

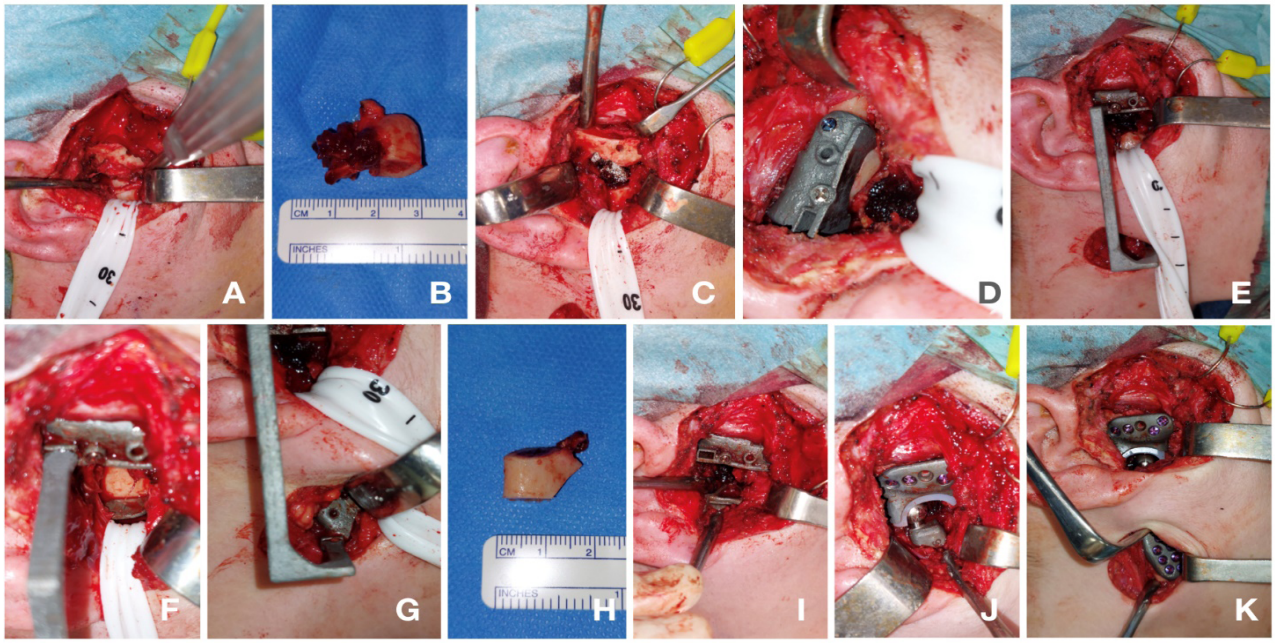

Figure 3. Patient with osteoarthrosis of the TMJ (Wilkes V TMJ pain-dysfunction syndrome). A: view of the mandibular condyle and articular eminence with signs of osteoarthrosis; B, C: removal of the cranial part of the mandibular condyle to create a gap; D: placement of the titanium alloy cutting guide at the level of the fossa/eminence and osteotomy following the cutting plane; E: placement of titanium alloy positioner to reference the placement of the mandibular ramus cutting guide in relation to the fossa/eminence cutting guide; F: cranial propulsion of the mandibular ramus and placement of the cutting guide of the mandibular ramus, to perform the osteotomy following the cutting plane marked by the cutting guide; G, H, I: view of the defect after removal of the caudal part of the mandibular condyle; J, K: placement of custom-made total TMJ prosthesis (maxillary system).

In summary, 1) alloplastic reconstruction of the TMJ with a custom-made total prosthesis constitutes the "gold standard" in the reconstruction of the final stages of joint disease with alterations in the anatomy or alteration of the mandibular position; 2) the stock total prosthesis can still play a role in non-complex cases (without alteration of the anatomy), due to the reduction in costs and savings in delivery time; 3) the use of surgical guides for cutting and positioning the screws designed through virtual planning allows increasing the precision in the mandibular and fossa components of the TMJ prosthesis; 4) it is necessary to evaluate the effectiveness of the new "custom-made" prosthetic designs through clinical studies that evaluate them in terms of clinical efficacy in the medium and long term and absence of complications; and 5) while metal 3D printing using additive techniques may be the future for manufacturing joint replacement devices, it is still in the early days of its development, and the fundamental relationships between processing, micro-structure and properties are not yet completely understood. It is likely that the future will involve: 1) the implementation of biomaterials that minimize prosthetic wear and tribocorrosion, 2) the design of prosthetic systems that minimize the size of their components without reducing their stability and improve their functionality (condylar translation and movements of laterality); and 3) the reduction of costs and delivery time, surgical training and virtual planning that "democratize" the use of total joint replacement systems.

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