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Christensen vs Biomet Microfixation alloplastic TMJ implant: Are there improvements? A numerical study

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ABSTRACT

The objective of this study was to compare the load transfer mechanism and behavior of two total temporomandibular joint (TMJ) prostheses: Biomet and Christensen TMJ models were simulated.

Computed tomography (CT) images from a specific patient were used to generate two models for use in simulation of implantation for the total temporomandibular prostheses. Three finite element models were created in all. One considered the intact temporomandibular joint and two received a temporomandibular implant. In the simulation we considered the five most important muscles acting on the mandible and incisor teeth support.

The Christensen model reduced strain in the opposite condyle by around 50% while increasing strain in the implanted condyle. The changes in the posterior side of the implanted condyle present an increase of five times the minimum principal strain, suggesting some bone fatigue. With the Biomet implant, the reduction in strain in the implanted condyle on the posterior side was around 100%, suggesting the possibility of some bone loss proximally near the resection plane.

Based on our results, we conclude that in both models the implants influence the behavior of the mandible by improving the symmetry of the mandible and strain distribution. The Biomet implant modifies the behavior of the mandible slightly and presents some improvements over the Christensen TMJ model in strain distribution and tensions in the opposite intact disc similar to the non-implanted situation.

1. Introduction

Temporomandibular disorders affect more than 10 million Americans (May et al., 2001). Several diseases have been described in the literature as affecting the temporomandibular joint (TMJ), but only a small group require surgical intervention (Sidebottom and Surg, 2008; Landes et al., 2014; Shen et al., 2014), mainly for biomechanical improvement including pain reduction, and increasing maximum bite force and maximum interincisal opening (Linsen et al., 2013). The TMJ prosthesis presents some advantages over other conservative techniques, it reduces the duration of surgery, reduces morbidity and provides function immediately (Quinn, 2000). However, it also presents some disadvantages compared with other conventional solutions: in the short term the cost of the prosthesis; and in the long term material wear, corrosion and particles (Royhman et al., 2014), also failure of the implant components and screws may lead to screw loosening (Mercuri, 1998). Many factors of failure are associated with wear between components and the screw fixings (Quinn, 2010; Shen et al., 2014). A defective alignment of the TMJ will cause an excessive load on one side of the mandible (Quinn, 2000; Giannakopoulos et al., 2012) with wear to the articular structures affecting the pterygoid muscle and causing pain.

There are two different types of TMJ implant on the market, custom-made and stock models. Each has some advantages and disadvantages associated with their geometry. Currently, only three standard TMJ prosthetic systems are available (Sanovich et al., 2014; Guarda-Nardini et al., 2008) that are approved by the FDA: TMJ Concept, Christensen System (Ventura, CA, USA); TMJ Medical (Nexus CMF, Salt Lake City, UT, USA); and the Biomet/Lorenz Microfixation TMJ replacement system (Jacksonville, FL, USA). In

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the standard model one of the best known TMJ implants is the Christensen implant, a metal–metal system with screw fixation on the condyle and the fossa components (Driemel et al., 2009).

The last report from the UK on TMJ replacement (Idle et al., 2014) refers to a decrease in the number of operations in the last two years (2011 and 2012) with 10% associated with prosthesis revision. In recent years several reports about the Biomet/Lorenz Microfixation replacement system have been published (Giannakopoulos et al., 2012; McKenna, 2012; Leandro et al., 2013), presenting short-term clinical results. These results have revealed improvements in the short term, up to 3 years, and stabilization after 4 years. The main advantage is the pain reduction at 6 months after the surgery.

These TMJ systems have not been compared in long-term studies; in 100 custom-made TMJ prostheses Wolford (2007) describe poor results in 14% of patients and fair results in 23% after an average time of 30 months, with some patients allergic to one or more components. This problem, and the corrosion due to wear in a metal–metal technology were the main reasons for the first Christensen TMJ system models to be discontinued on the market (Sidebottom et al., 2008), it has been reintroduced as TMJ Medical. Problems have become more critical since the first cases of TMJ reconstruction surgery were reported in young patients (mean age: 40.9 years; SD: 10.3) (Mercuri et al., 2007).

The main research hypothesis was that the Biomet/Lorenz Microfixation total TMJ implant offers improvements on the behavior of the Christensen TMJ used frequently in the past and reintroduced again by TMJ Medical (Nexus CMF).

2. Materials and methods

To compare the different behaviors of implanted TMJ, two models were used, one with a Biomet implant and the other with a Christensen total TMJ implant. The intact and implanted models were generated from computer tomography images, four different structures were considered: the skull, mandible, articular discs and articular cartilages. The models used in this study were based on CT scans of a 47-year-old female patient using Simpleware software. The mandible was discretized into cortical and cancellous bone using previously defined values for Hounsfield units (Bujtár et al., 2014) and the articular discs and articular cartilages in the intact model were manually refined to differentiate them from the adjacent soft bone, shown in Fig. 1. In our study, the teeth were not considered and did not influence mandibular behavior (Korioth et al., 1992; Ichim et al., 2007).

2.1. Implanted models

There were two models with a total TMJ implant, one with a Biomet/Lorenz Microfixation TMJ and one with a Christensen TMJ, shown in Fig. 2 with the implants in position. The positioning of the implant was considered to be the natural position of the contact point in the native condition; this was supervised by a maxillofacial surgeon.

Short-term clinical results have been published for the Biomet/Lorenz Microfixation (BM) replacement system, which revealed improvements in the short term, up to 3 years, and stabilization after 4 years. The implant is made up of two components: the fossa is of medium size and made of ultra-high-molecular-weight polyethylene (UHMWPE), and the condyle is 50 mm in length and made of cobalt chromium alloy. The system was fixed with 5Al/4V titanium screws. In the BM model fixation was with five 2 mm diameter screws in the fossa and five 2.7 mm diameter bi-cortical screws in the mandible.

Several studies have been published on the Christensen TMJ model (CM) from TMJ implant (TMJ Implants, Inc., Golden, CO, USA), which have shown poor results in the long term (Wolford et al., 2003; Mercuri et al., 2007; Kanatas et al., 2012). This implant solution has two components (condyle and fossa) made of cobalt chromium alloy with three screws in the fossa and nine screws in the condyle. One model of the fossa component geometry was chosen as the best geometry for the cranium and was positioned as a standard position in the bone, as occurs with a real patient. Fixation to the condyle was with nine 2.7 mm diameter bi-cortical screws, and the fossa component was with eight 2 mm screws.

2.2. Finite element models

Finite element (FE) models were used to simulate mandibular behavior and were created with four-node finite tetrahedral

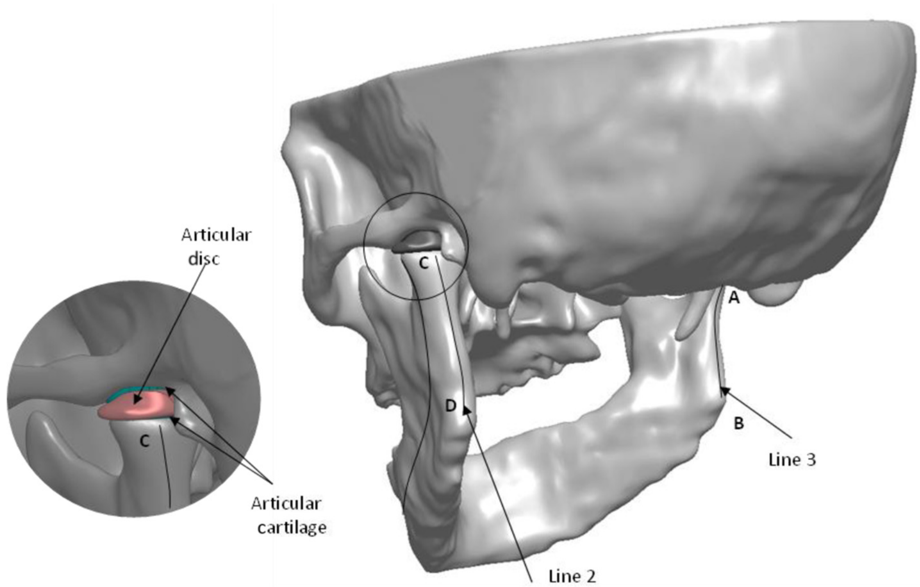

Fig. 1. Intact model of bone structures and cartilage after reconstruction (showing lines 2 and 3 for results).