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Temporomandibular joint fibrocartilage degeneration from unilateral dental splints

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ABSTRACT

Objective: The objective of this study was to determine the extent to which altered loading in the temporomandibular joint (TMJ), as might be associated with a malocclusion, drives degeneration of articulating surfaces in the TMJ. We therefore sought to quantify the effects of altered joint loading on the mechanical properties and biochemical content and distribution of TMJ fibrocartilage in the rabbit.

Design: Altered TMJ loading was induced with a 1 mm splint placed unilaterally over the maxillary and mandibular molars for 6 weeks. At that time, TMJ fibrocartilage was assessed by compression testing, biochemical content (collagen, glycosaminoglycan (GAG), DNA) and distribution (histology), for both the TMJ disc and the condylar fibrocartilage.

Results: There were no changes in the TMJ disc for any of the parameters tested. The condylar fibrocartilage from the splinted animals was significantly stiffer and the DNA content was significantly lower than that in control animals. There was significant remodeling in the condylar fibrocartilage layers as manifested by a change in GAG and collagen II distribution and a loss of defined cell layers.

Conclusions: A connection between the compressive properties of TMJ condylar fibrocartilage after 6 weeks of splinting and the changes in histology was observed. These results suggest a change in joint loading leads to condylar damage, which may contribute to pain associated with at least some forms of TMJ disease.

1. Introduction

The development of effective interventions for the treatment of temporomandibular joint (TMJ) disorders (TMD) has been hindered by the fact that preclinical models of TMD inadequately reflect the pathology of the human state. Patients who undergo surgery often have both pain and abnormal joint functional loading.[1,2] In more severe cases, there is also degeneration of the articulating tissues, including the TMJ disc and the condylar fibrocartilage.[3] However, it is not clear whether abnormal loading leads to degeneration and then pain, or degeneration leads to abnormal loading and pain. In support of the latter, trauma, internal derangement,

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and parafunctional habits are all thought to be able to initiate the cascade of events that lead to TMD.[3,4] The link between parafunctional habits and TMD would also support the suggestion that altered loading is the cause rather than the effect in the case of TMD where, in the case of bruxism (clenching), joint overloading would lead to biochemical changes in the synovial fluid and painful inflammation, which then causes adhesions and immobilization of the joint, leading to further alterations to the articulating surfaces.[1] In severe cases, the alteration could be a pathological process of joint degeneration, such as osteoarthritis, which is characterized by deterioration and abrasion of the articulating fibrocartilage and local thickening and remodeling of the underlying bone.[5]

Unfortunately, despite the development of several different preclinical models designed to drive TMD by changes in joint loading,[6–19] there have been no detailed analyses of the articulating surfaces in the TMJ. Rather, changes to the articulating surfaces have only been suggested with results of histological analysis where differences in the distribution of extracellular matrix components in the condyle have been described.[13,14] However, the mechanical properties and quantitative biochemical properties of the fibrocartilage are lacking, which can give more insight into the degeneration process.

Therefore, the objective of this study was to determine the effects of altered TMJ loading on the properties of TMJ fibrocartilage. TMJ fibrocartilage was assessed mechanically in compression and the biochemical content and distribution were determined. The hypothesis was that altered mechanical and biochemical properties and disorganized cellular presence in histology would serve as indicators for the presence of remodeling.

2. Materials and methods

2.1. Animal model

The majority of previous TMD animal studies have been completed on small rodents.[20] However, these small rodent animal models do not lend themselves to mechanical analysis of the articulating joint tissue, while the TMJ's main function is mechanical support of jaw movement. Consequently, the rabbit model was used in the present study, taking advantage of the facts that there is sufficient articulating joint tissue for mechanical analysis and TMJ injury and degeneration models already established in the literature.[13,18,20–26] A unilateral molar splint, [13,17,18] was chosen for this study because it is associated with altered TMJ loading, in the absence of a direct manipulation of the joint, and most closely mirrors changes driven by a sudden change in malocclusion occurring from trauma or a radical dental procedure.

Skeletally mature, female, New Zealand White rabbits approximately 1 year in age and weighing between 5 and 7 kg were purchased from Myrtle's Rabbitry Inc. (Thompsons Station, TN), and Charles River Laboratories International, Inc. (Wilmington, MA). All rabbits were examined by a veterinarian prior to use in the study and were found to be in good health. All animal procedures were approved by the Institutional Animal Care and Use Committee at the University of Pittsburgh and in accordance with the National Institutes of Health guidelines for the use of laboratory animals.

All of the experimental group (splinted) rabbits were sedated with intramuscular ketamine (20 mg/kg) and xylazine (2 mg/kg), and maintained in a surgical plane of anesthesia with inhaled 2% isoflurane for two separate procedures: impressions and splint placement. During the first procedure, impressions were taken of the upper and lower right molars (Fig. 1A). Non-precious metal bite-raising splints were cast as crowns on molds made from the impressions (Fig. 1B). The thickness of each splint was approximately 1 mm. During the second procedure, the right molars were cleaned (with water and a cotton swab to remove food debris) and primed (with 34% Phosphoric Acid Tooth Conditioner Gel, Dentsply International Inc., Milford, DE), and the splints were attached with dental cement (GC FujiCEM 2, GC Corporation, Tokyo Japan) (Fig. 1C). Splint placement was verified after 1 week of placement. There were some animals (approximately 50%)

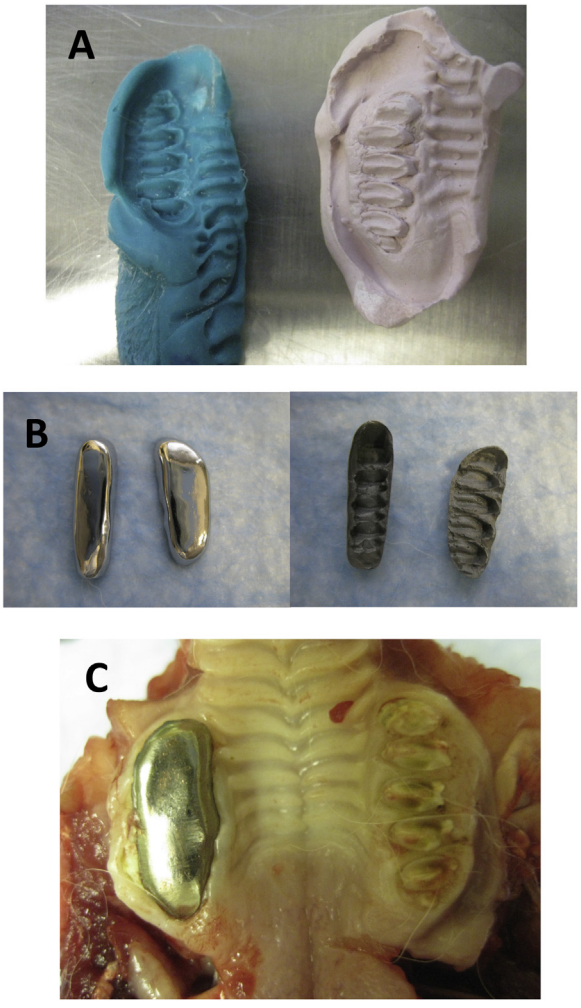

Fig. 1 – Unilateral molar bite-raising splints. (A) The splints were made by first taking an impression of the teeth, from which a plaster mold was made. (B) The metal splints were cast as crowns, the superior and inferior views are shown. (C) Upper splint in place after 6 weeks.