Brief Communication

Preliminary Investigation of a Novel Mouthguard

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Abstract

Background: Mouthguards (MGs) remain an important piece of personal protection for athletes for the prevention of injury. Although MGs provide tremendous benefits, the design and fabrication process does not record the position of the mandible or the occlusion, which could lead to injury. This study compared a novel MG to over-the-counter (OTC) and custom MGs on a skull model. **Methods:** The OTC MG was formed as per manufacturer's guidelines, the custom MG was laboratory fabricated, and the novel MG was fabricated through a proprietary process. Each group of the three MGs was assessed for vertical dimension change, occlusal contacts, and condylar displacement. **Results:** Average number of occlusal contacts for the OTC, custom and novel MG were 2.4, 4.0, and 10, respectively. There was a significant difference between all values ($P < 0.05$). Average change in vertical dimension for the OTC, custom, and novel MG were 15.3 mm, 9.3 mm, and 8.0 mm, respectively. The novel MG value was significantly different ($P < 0.05$). The average distance of condylar displacement for the OTC, custom and novel MG were 1.9 mm, 1.3 mm and 0.6 mm, respectively. **Conclusions:** The novel MG was significantly different ($P < 0.05$). The data from this preliminary investigation suggests that the novel mouthguard had maximized occlusal contacts, minimized vertical dimension change and condylar displacement as compared to OTC and custom MGs.

Keywords: *Occlusion, oral appliance, vertical dimension*

Introduction

Mouthguards (MGs) remain an important piece of personal protection for athletes for the prevention of injury.[1] MGs are recommended for 29 sport activities by the American Dental Association[2] and mandatory by the National Collegiate Athletic Association for ice hockey, field hockey, and lacrosse.[3] The function of the MG is to provide a shock absorbing layer with the purpose of reducing the stress of an impact and subsequent injury to the teeth, soft tissues, maxilla, mandible, and temporomandibular joint complex.[2] MGs are available as either an over-the-counter product (OTC), where consumers are expected to approach it with a do-it-yourself boil and bite process or through a dentist, where a mold of the top teeth is taken and a customized laboratory-fabricated intra-oral appliance is delivered.[4]

Although MGs provide tremendous benefits, the design and fabrication process results in several variables,[4] including as follows: material thickness, material type, fit, and retention. These variables can affect athlete communication, breathing, and compliance.[5] In addition, there is no record of the mandible or occlusion. Without respecting the occlusion, there is the potential for unequal forces, increased pressure, pain, temporomandibular disorder, and malocclusion disorders.[6,7] Failure to respect occlusion with scuba mouthpieces has been reported,[8] and MGs incorporate similar materials with parallel concerns. The aim of this study was to develop an alternative MG that maximized occlusal contacts and minimized mandibular positional change.

Methods

This comparison study employed an anatomical skull model (Kilgore International: Coldwater, Michigan, USA). Nine MGs were employed, three from each category: OTC, dentist-delivered (custom) and novel. The OTC MG was fitted by following the manufacture's guidelines and on the model by warming then molding the MG [Figure 1a]. The custom MG was delivered by obtaining an impression with replication silicone (Counterfeit: Clinician's Choice: London, Ontario, Canada) of the maxilla and having a laboratory fabricated appliance (Shaw Labs: London, Ontario,

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Figure 1: Over the counter (left), custom (middle), and novel (right) mouthguard on anatomical skull model

Canada) in accordance with standard laboratory prescription guidelines at the Schulich dental school [Figure 1b]. The novel appliance required standard records obtained with impressions with replication silicone (Counterfeit: Clinician's Choice, London, Ontario, Canada) of the maxilla and mandible, bite registration (Quick Bite: Clinician's Choice, London, Ontario, Canada) and a facebow (Whip Mix: Louisville, Kentucky, USA) record. The impressions were poured in jade stone (Whip Mix: Louisville, Kentucky, USA) and mounted accordingly. The novel appliance was fabricated through a proprietary process and fitted on the skull [Figure 1c]. Details of the novel MG remain confidential pending intellectual property protection.

The three MGs were assessed on the skull models for the change in vertical dimension measured in millimeters, from the inferior aspect of the MG to the superior aspect of the mandibular incisors, the number of occlusal contacts and the distance of condylar displacement, measured from the inferior aspect of the glenoid fossa to the superior aspect of the head of the temporomandibular joint. The distance was measured with a Mastercraft digital caliper (Canadian Tire: Toronto, Ontario, Canada) and the occlusal contacts were marked with horseshoe articulating paper and then visually counted. Data analysis involved the following: values were compared using a one-way ANOVA, statistical significance alpha was set at 95% and Tukey's method distinguished the significant groups.

Results

Results are displayed in Table 1. The average number of occlusal contacts for the OTC, custom, and novel MG were 2.4, 4.0, and 10, respectively. Values were significantly different ($P < 0.05$). The average change in vertical dimension for the OTC, custom, and novel MG were 15.3 mm, 9.3 mm, and 8.0 mm, respectively. The novel value was significantly different ($P < 0.05$). The average distance of condylar displacement for the OTC, custom, and novel MG were 1.9, 1.3, and 0.6, respectively. The novel MG value was significantly different ($P < 0.05$).

Table 1: Average parameters of over the counter, custom, and novel mouthguards

Parameter	OTC	Custom	Novel
Occlusal contacts	2.4	4.0	10.0
Vertical dimension (mm)	15.3	9.3	8.0
Condylar displacement (mm)	1.9	1.3	0.6

OTC=Over-the-counter

Discussion

The occlusal contacts for the OTC MG were the lowest, followed by the custom MG. The novel MG had the highest number of occlusal contacts. Maximizing occlusal contacts is necessary to increase the dissipation and transmission of force and lessen the chance for injury,[9] especially if a force targets the mandible upward. The OTC MG had the largest change in vertical dimension, followed by the custom MG and then the novel MG. A minimal change in vertical dimension provides a more neutral condylar position and increased stability.[10] The average distance of condylar displacement was the highest for the OTC MG, followed by the custom MG and then the novel MG. A minimal condylar displacement is preferred,[11] as a larger displacement increases the chance for internal injury.[12]

This investigation was limited by a small sample size, an anatomical skull, possible distortion of dental materials and the subjectivity of occlusal assessment. Further research is warranted on a larger sample size with patients, with more objective measurement techniques and on the prevalence of dental problems with long-term MG use.

A novel MG has been developed and assessed on an anatomical skull model. Based on the methodology used and the results obtained, the data suggested that the novel appliance had maximized occlusal contacts, minimized a change in vertical dimension and condylar displacement as compared to OTC and custom MGs. The novel appliance has been developed, with a unique approach to design and fabrication, addressing the shortcomings of OTC and dentist-delivered MGs. As the necessity for personalized medicine and dentistry increases, the importance of occlusally driven mouthguards will play an increased role in injury prevention.

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Conflicts of interest

Les Kalman is the developer of the novel mouthguard.

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