SHORT REPORT

Influences of palatal side design and finishing on the wearability and retention of mouthguards

Y Maeda, H Machi, T Tsugawa

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Objectives: To examine the influences of design and finishing on mouthguard wearability and retention.
Materials and methods: 17 students at the Dental Technician Institute at Osaka University School of Dentistry, Osaka, Japan, participated in this study after providing informed consent. For each student, a single-layer custom-made mouthguard was fabricated from a 3.8-mm-thick ethylene-vinyl acetate sheet using a standardised procedure to obtain a precise fit. Each mouthguard was modified by changing the margin location and shape through five consecutive steps. At each step, questionnaires with a visual analogue scale regarding wearability (comfort, breathing, speaking, swallowing, lip closure, temporomandibular joint fatigue and swallowing) and retention were completed by subjects after wearing the mouthguard for 5 min. Statistical analyses were carried out among the steps using Wilcoxon's signed-rank test with a significance level of $p<0.05$.
Results: Significant improvements were found for comfort, breathing, speaking and swallowing by trimming the palatal margin to the cervical area, smooth finishing and occlusal adjustment of the mouthguard ($p<0.01$). No significant differences were found for retention throughout the procedure.
Conclusions: Within the limitations of this experimental study, design and finishing at the palatal side appear to have significant influences on mouthguard wearability, but not retention.

Using a mouthguard is an effective measure for preventing or reducing traumatic injuries to the orofacial region during various types of sporting events such as American football, basketball, rugby and ice hockey.[1–5] However, some athletes are reluctant to wear a mouthguard. The main reasons for this reluctance are generally related to wearability, including concerns such as discomfort, and difficulties in breathing and speaking.

DeYoung *et al*[6] reported that athletes preferred the custom-made mouthguards to self-adapted mouthguards in terms of comfort and wearability. McClelland *et al*[7] reported the effects of labial extension, occlusal contact and peripheral finishing of custom-made mouthguards on their wearability. They indicated that comfort is likely to increase if mouthguards are extended labially to within 2 mm of the vestibular reflection, adjusted to allow even occlusal contact, rounded at the buccal peripheries and tapered at the palatal edges. Kenyon and Loos[8] compared the wearabilities of single-layered vacuum-formed ethylene-vinyl acetate (EVA) mouthguards and double-layered heat-laminated and pressure-laminated EVA mouthguards.

Although the palatal side of oral appliances is critical to pronunciation and breathing, the palatal side design of mouthguards has been studied mainly in relationship to the shock absorption capability and retention, rather than in relation to wearability.[9]

The working hypothesis of the present study was as follows: if a mouthguard can be ensured to fit properly, the palatal margin can be shortened to the cervical area to improve wearability, including aspects such as comfort, breathing and pronunciation, without sacrificing retention. The purpose of this study was to test the above-mentioned hypothesis by examining the influences of palatal side design and finishing on the wearability of mouthguards.

MATERIALS AND METHODS

A total of 17 students (4 men and 13 women; average age 22.3 years) at the Dental Technician Institute at Osaka University School of Dentistry participated in this study after providing informed consent. For each student, a single-layer custom-made mouthguard was fabricated from a 3.8-mm-thick EVA sheet using a standardised procedure and a pressure-forming machine (Erkopress 2S; Erkodent, Germany) to obtain a precise fit. Each mouthguard was modified by changing the margin location and shape by the following five consecutive steps.

La-2: After trimming of the buccal margin to 4 mm from the vestibular reflection area as well as the palatal margin to the cervical area, the posterior border was set at the distal aspect of the first molar (fig 1).

La-3: After occlusal adjustment on the articulator to achieve even contact on both sides of the premolar and molar regions, the vertical dimension was adjusted to a 3-mm increase at the central incisor.

Cl-1: The same procedure as La-2 was carried out on a different day.

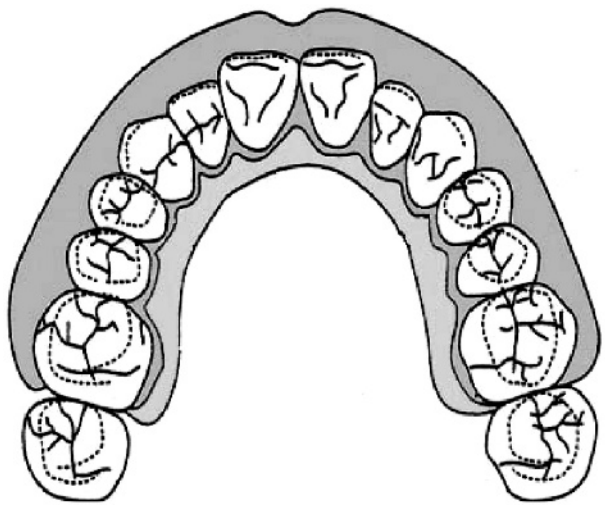

Figure 1 Design of mouthguard,with palatal margin trimmed to the cervical margin of each tooth in step La-2.

Abbreviations: EVA, ethylene-vinyl acetate; TMJ, temporomandibular joint

Table 1 p Values for the change in wearability and retention between steps

	La1–La2 Margin location	La2–La3 Occlusal adjustment	Cl1–Cl2 Occlusal adjustment
Occlusion	0.820	0.001**	0.001**
Pronunciation	0.001**	0.001**	0.088
Discomfort	0.005**	0.001**	0.002**
Breathing	0.191**	0.002**	0.102**
Retention	0.692	0.162	0.03
Lip closure	0.002**	0.084	0.112
Fatigue in muscle	0.266	0.017*	0.001**
Swallowing	0.001**	0.005**	0.093
Vomiting	0.46	0.609	0.701

*p<0.05; **p<0.01.

Cl-2: Occlusal and peripheral adjustments were made by a dentist.

After each step, the participants were asked to fill out questionnaires with a visual analogue scale (maximum, 10; minimum, 0) regarding the wearability (comfort, breathing, pronunciation, swallowing, lip closure and temporomandibuler joint (TMJ) fatigue) and retention after wearing the mouthguard for 5 min. Statistical analyses were carried out among the steps using Wilcoxon's signed-rank test with a significance level of $p<0.05$.

RESULTS

Significant improvements were found for comfort, breathing, pronunciation and swallowing after the palatal margin location of the mouthguards had been changed ($p<0.01$) (table 1). Occlusal adjustments on the articulator also significantly improved the discomfort (average, 2.4–4.4), breathing (average, 6.1–7.8), pronunciation (average, 4.1–7.3) and swallowing (average, 6.1–8.1; all $p<0.01$), as well as fatigue in the TMJ (average, 4.5–6.4; $p<0.05$ table 1, fig 2). Adjustments to the occlusion and periphery by a dentist significantly improved the discomfort (average, 3.8–6.2) and TMJ fatigue (average, 5.7–7.6); both $p<0.01$. No statistical differences were found for retention (average, 5.8–7.4) among the five steps.

DISCUSSION

Although mouthguards have been reported to be effective in preventing traumatic injuries during various sporting events, some athletes are still reluctant to wear one. The main reasons for this reluctance are discomfort, difficulties in speaking and breathing, and fatigue in the TMJ. Regarding breathing or air intake with a mouthguard, several reports have indicated that mouthguards usually have no significant side effects.[10 11]

To solve the remaining problems, changes to mouthguard design and finishing, including occlusal adjustments and polishing, should be carefully considered once the precise fit of a mouthguard has been achieved with a well-dried working model.[12]

The area involved in most of these problems is the palatal side of the maxillary arch, which the tongue touches during pronunciation or swallowing. Although the designs of removable oral appliances such as complete dentures,[13] partial dentures and implant-supported prostheses[14] on the palatal side have been examined, there has been little research on mouthguard design.

Reduction in the thickness and placement of the palatal margin at the cervical area can be the most effective measures for minimising these problems. However, these

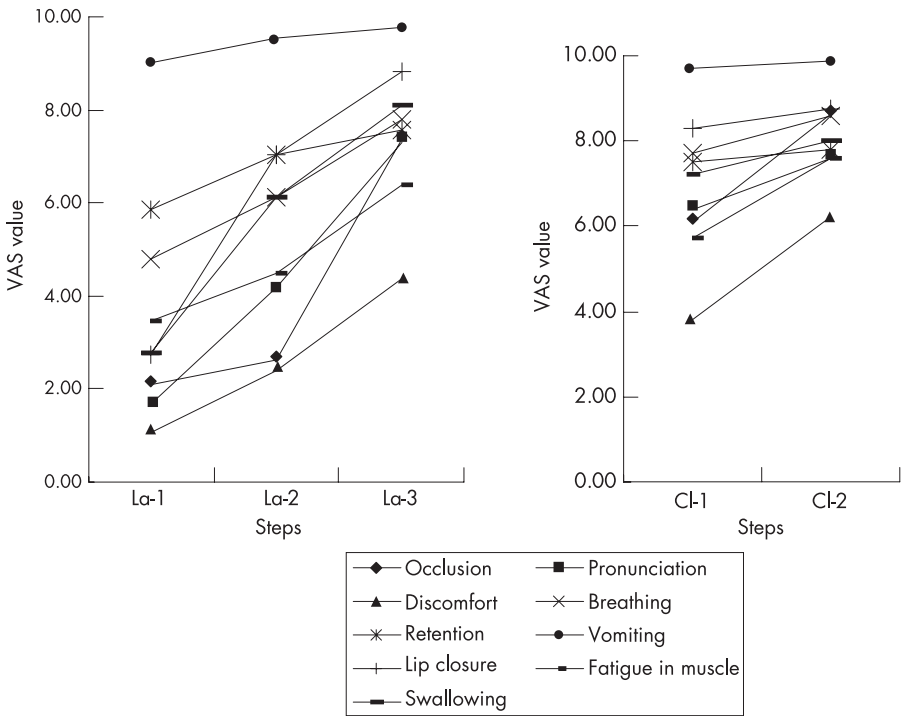

Figure 2 Changes in visual analogue scale (VAS) values in relation to experimental steps.

What is already known on this topic

Using a mouthguard is an effective measure for preventing or reducing traumatic injuries to the orofacial region during various types of sporting events However, some athletes are reluctant to wear a mouthguard, and the main reasons for this reluctance are generally related to wearability, including concerns such as discomfort and difficulties in breathing and speaking

What this study adds

If a mouthguard can be ensured to fit properly, the palatal margin can be shortened to the cervical area to improve wearability, including aspects such as comfort, breathing and pronunciation, without sacrificing retention

changes may also cause a reduction of retention. In our previous in vitro study, we showed that the retention of a mouthguard does not change with differences in the margin location as long as the precise fit of the mouthguard is maintained.[15] The present results further confirm that shortening of the palatal margin to the cervical area does not affect the retention, although it significantly improves the comfort, pronunciation and swallowing.

The occlusal mouthguard adjustments in this study significantly improved the discomfort, pronunciation and TMJ fatigue, consistent with the study by McClelland *et al*.[7] The above-described freedom of margin placement and occlusal adjustments also demonstrate that custom-made mouthguards show superior wearability compared with other types of mouthguards.

CONCLUSION

Within the limitations of this experimental study, design and finishing at the palatal side appear to have significant influences on mouthguard wearability, but not retention.

Authors' affiliations
Y Maeda, T Tsugawa, Osaka University School of Dentistry, Division for Interdisciplinary Dentistry, Osaka, Japan
H Machi, Osaka University School of Dentistry, Institute for Dental Technology, Osaka, Japan

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Correspondence to: Y Maeda, Osaka University, 1-8 Yamadaoka Suita, Osaka 565-0871, Japan; ymaeda@dent.osaka-u.ac.jp

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REFERENCES

1 **McNutt T**, Shannon SW Jr, Wright JT, *et al*. Oral trauma in adolescent athletes: a study of mouth protectors. *Pediatr Dent* 1989;**11**:209–13.
2 **Labella CR**, Smith BW, Sigurdsson A. Effect of mouthguards on dental injuries and concussions in college basketball. *Med Sci Sports Exerc* 2002;**34**:41–4.
3 **Kumamoto D**, Maeda Y. Are mouthguards necessary for basketball? *J Calif Dent Assoc* 2005;**33**:463–70.
4 **Quarrie KL**, Gianotti SM, Chalmers DJ, *et al*. An evaluation of mouthguard requirements and dental injuries in New Zealand rugby union. *Br J Sports Med* 2005;**39**:650–1.
5 **Berry DC**, Miller MG, Leow W. Attitudes of Central Collegiate Hockey Association ice hockey players toward athletic mouthguard usage. *J Public Health Dent* 2005;**65**:71–5.
6 **DeYoung AK**, Robinson E, Godwin WC. Comparing comfort and wearability: custom-made vs. self-adapted mouthguards. *J Am Dent Assoc* 1994;**125**:1112–18.
7 **McClelland C**, Kinirons M, Geary L. A preliminary study of patient comfort associated with customised mouthguards. *Br J Sports Med* 1999;**33**:186–9.
8 **Kenyon BJ**, Loos LG. Comparing comfort and wearability between Type III single-layered and double-layered EVA mouthguards. *Gen Dent* 2005;**53**:261–4.
9 **Yamada J**, MaedaY, Satoh H, et al. Anterior palatal mouthguard margin location and its effect on shock-absorbing capability. *Dent Traumatol* 2006;**22**:139–44.
10 **Francis KT**, Brasher J. Physiological effects of wearing mouthguards. *Br J Sports Med* 1991;**25**:227–31.
11 **Amis T**, Di Somma E, Bacha F, *et al*. Influence of intra-oral maxillary sports mouthguards on the airflow dynamics of oral breathing. *Med Sci Sports Exerc* 2000;**32**:284–90.
12 **Yonehata y, Maeda Y, Machi H, et al**. The influence of working cast residual moisture and temperature on the fit of vacuum-forming athletic mouth guards. *J Prosthet Dent* 2002;**89**:23–7.
13 **Petrovic A**. Speech sound distortions caused by changes in complete denture morphology. *J Oral Rehabil* 1985;**12**:69–79.
14 **Heydecke G**, McFarland DH, Feine JS, *et al*. Speech with maxillary implant prostheses: ratings of articulation. *J Dent Res* 2004;**83**:236–40.
15 **Maeda Y**, Yonehata Y, Satoh H. The influence of design and accuracy of fit on mouth guard retention. An in-vitro study. *Quintessence Int* 2006. In press.

COMMENTARY

It is always helpful to encourage athletes to compete in their chosen sport safely. Making a mouthguard more acceptable by way of better wearability for participants in contact sports is one way of ensuring that injuries are minimised. Evidence shows us that wearing a custom-made mouthguard reduces the incidence of orofacial injuries in contact sports. Mouthguards are often too big and bulky, but those that are easy to wear and are well tolerated by sportsmen and women will significantly reduce the incidence of injury; however, athletes not wearing mouthguards must be educated about the benefits of their use.

D G Patrick
University of Sheffield, Oral Health & Development, Sheffield, UK;
d.g.patrick@sheffield.ac.uk