

## FEATURES SECTION

# Mouthguards and orthodontic patients

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All orthodontic patients who wear fixed appliances and participate in contact sports are recommended to wear a mouthguard for protection against dental trauma and injury. An overview of the different types of mouthguards currently available is described together with their relative suitability for orthodontic patients.

*Key words:* Sports, dental trauma, fixed appliances, mouth formed mouthguard, custom made mouthguard

## Introduction

The participation in sports carries the risk of sustaining some form of dental injury. There are many patients, especially adolescents who, while undergoing orthodontic treatment participate in contact sports without benefiting from the protection of mouthguards. Most orthodontic treatment is carried out before or during adolescent years. It is during these years when there is a reported peak in the incidence of dental trauma while participating in contact sports.<sup>1</sup> When a child is wearing an orthodontic appliance, a potential oro-facial injury can occur more easily resulting in additional damage to soft tissues. A blow to the appliance can lead to the loosening of brackets and bending of archwires. A contact sport is defined as sports in which players physically interact with each other, trying to prevent the opposing team or person from winning.<sup>2</sup> Competitive matches are deemed more hazardous than a training session. Contact sports include rugby, basketball, football, as well as 'stick sports' such as lacrosse, hockey and ice hockey. Other common activities in which young people participate in such as cycling and skateboarding could also result in dentoalveolar trauma.

In children, sports accidents reportedly account for 10–39% of all dental injuries,<sup>3</sup> and can often involve teeth with incomplete root formation.<sup>4</sup> Boys are more likely to incur injuries than girls<sup>5</sup> with a peak incidence of 8 to 11 years.<sup>6</sup> The vast majority of dental trauma and injuries affect the upper jaw. Injury to the maxillary incisors is very common and can account for as much as 80% of all cases.<sup>7</sup> Common dental injuries include avulsion and subluxation of teeth, laceration to lips, damage to the surrounding structure of teeth, chipped

teeth, concussion and dento-alveolar and facial bone fracture. Patients with class II division 1 incisor malocclusions, with an associated increased overjet and proclined upper incisors are more prone to trauma.<sup>8</sup>

A mouthguard is a resilient device placed inside the mouth to help reduce injuries to the teeth and associated tissues. It works by absorbing some of the energy from a direct blow at the site of impact and dissipating the remaining energy by cushioning and redistributing the force.<sup>9</sup> This leads to a reduction in transmitted forces to the underlying teeth and orofacial tissues and the mouthguard holds the soft tissues of the lips and cheeks away from the sharp edges of the teeth, leading to a reduction in lacerations and soft tissue injuries.<sup>9</sup> They offer considerable protection in preventing dentoalveolar injuries when properly fitted, and may also have some benefits in preventing concussion<sup>10</sup> and possibly temporomandibular joint injuries.<sup>11</sup>

Mouthguards are generally made from ethylene vinyl acetate (EVA). Originally a single sheet of 3–5 mm thick EVA polymer was used and placed on a plaster cast model from an impression of a patient's mouth, in a vacuum forming machine. EVA's properties include being non-toxic, elastic, having minimal moisture absorption and ease of manufacture.<sup>12</sup> More recently, pressure laminated mouthguards have been introduced, which consist of two or more laminate layers fused together by heat and pressure on a dental model. These are more attractive with a wide range of designs and colours available, as well as having a very good fit. A properly designed and fitted mouthguard is recommended.<sup>13,14</sup> This article aims to review the different mouthguards currently available to orthodontic patients with fixed orthodontic appliances.

## Classification of mouthguards

### *Stock mouthguards*

These are ready made mouthguards bought over the counter and come in different sizes to fit all sizes of mouths. They are designed to be used without any further modification and are made from polyurethane or a co-polymer of vinyl acetate or ethylene. They are generally regarded as being the least satisfactory as they offer minimum protection and give a false sense of security. They are generally inexpensive and convenient to buy from most sports outlets.

### *Mouth formed mouthguards*

These consist of a thermoplastic material which is immersed and heated in hot water in order to be softened. They are also known as a 'boil and bite' mouthguards. The mouthguard is then placed in the mouth and adapted and moulded to the teeth by biting, finger and tongue pressure. Traditionally these mouthguards, like the stock type, were bulky, uncomfortable and had poor retention. Some required constant biting to hold them in place. This can affect both speech and breathing. Any mouthguard that is held in position by continuous clenching of teeth is regarded as unsatisfactory and unsafe.<sup>15</sup> As well as a poor fit, they tend to be dimensionally thin over prominent teeth that are prone to damage. They are generally inexpensive and convenient to buy from most sports outlets.

More recently however, there have been some improvements with some that do not require to be softened in hot water. These have an instant fit with an incorporated channel to accommodate a fixed appliance and potential tooth movements. They are sufficiently flexible to adapt around the shape of teeth and orthodontic appliance (Figure 1). These try to address some of the deficiencies of the traditional 'boil and bite' mouthguards.

### *Custom made mouthguards*

These are specially made from a cast of a dental impression of a jaw taken by a dentist. These have traditionally been made by vacuum or pressure moulding using polyvinylacetate-ethylene copolymer (EVA). They are generally much more comfortable to wear than the other types and offer greater protection against trauma and concussion. They are not available over the counter. Some may find them expensive and they require a visit to the dentist. In Europe mouthguards are registered as personal protective equipment and must be certified by the manufacturer by a CE mark on the



**Figure 1** Shock Doctor Braces

product in order for it to be deemed appropriate as protective equipment. Dentists should ensure that custom made mouthguards have been appropriately marked in this way by the laboratory.<sup>16</sup>

One would expect that a patient would need to visit a dentist for an impression. However, there are companies advertising on the internet that offer custom made mouthguards if the patients take their own impression (Table 1). This is done using a self-impression kit provided by the company and can include tubs of impression putty, an impression tray, instructions and a freepost return package in which the impression is sent. Mouthguards can be customised and designed online to an individual's satisfaction, from multi-coloured stripes to pre-designed ready made options. One of the companies will also arrange impressions to be taken at the patient's school or sports club.

## Orthodontic requirements

Mouthguards for children undergoing fixed appliance orthodontic treatment should not be too closely adapted to the teeth or fixed appliances. Overly close adaptation to orthodontic brackets and archwires could result in these being debonded or distorted when the mouthguard is inserted or removed. In addition a disadvantage of a custom made mouthguard is that it may not fit properly over time as tooth movements occur. Where this happens the mouthguard will become painful during insertion and will not seat adequately.

Examples of orthodontic custom-made mouthguards for fixed appliance patients and their fabrication have been described in the literature.<sup>17-22</sup> The process

involves taking an upper alginate impression, casting a stone model, and blocking out areas to incorporate space to accommodate anticipated tooth movements and normal dental development. For example, areas where extraction spaces are to be closed or displaced teeth are to be brought into the line of the arch. The brackets, tubes and any other protruding parts of the appliance should also be blocked out. Plaster of paris, mortite (a window sealing compound) or other putty-like materials have been used for blocking out space to a thickness which will allow smooth insertion and removal of the mouthguard. These blocking out materials should be heat resistant during the vacuum forming process. A blank sheet of soft vinyl is then vacuum formed to the cast and trimmed. The blocking out may result in the mouthguard being a little less retentive but it should still contact the gingivae and engage the natural undercuts of the mouth. The lifespan of this type of mouthguard has been described as 6–18 months,<sup>21,22</sup> with closer adaptation to the model resulting in better retention, but with the disadvantage of more frequent modifications and replacement.<sup>20</sup>

Custom-made mouthguards can be specially designed and ordered on the internet, such as is provided by O-PRO (Table 1). They include the option for individuals wearing fixed or removable orthodontic appliances, bonded retainers and also allow the user to customize the degree of protection (single or trilaminar layers) depending on their sporting activity.

There are a number of non-custom orthodontic mouthguards available commercially. The mouth formed mouthguards such as 'Shock Doctor Braces' (Shock Doctor, Inc., 3650 Annapolis Lane, Suite 115, Plymouth, MN, USA) (Figure 1) has been specially designed for use by serious sports people who have an orthodontic fixed appliance. It does not need adaptation to the mouth by immersion in hot water and is ready for use straight away with an instant fit. The inner lining is



**Figure 2** Signature type 1

made from silicone which is flexible at room temperature and does not require softening in order to adapt around the shape of teeth, fixed appliance and soft tissues. It incorporates a special 'ortho-channel' that fits over a fixed appliance and can also accommodate orthodontic tooth movements. This is for single arch use. Signature type 1 (Signature Mouthguards Pty Ltd, Level 1, 9 Carlotta Street, Artarmon NSW, Australia) (Figure 2) and Powrgard 4Braces (Myofunctional research Co., Europe, 5144NN Waalwijk, Netherlands) (Figure 3) have all also been specially designed for use with orthodontic fixed appliances. These require them to be immersed in boiled water for 45–60s, positioned over the fixed appliances, bitten down on gently before soft tissue moulding with lips, fingers and tongue. The 'Powrgard 4Braces' series are available in single and double arch use.

There are examples of stock mouthguards for orthodontic use, which cover both upper and lower teeth and fixed appliances at the same time. These include the Masel Doubleguard (Masel, 2701 Bartram Road, Bristol, PA, USA) (Figure 4) which has a special hinge to keep the mouthguard in place in the mouth, TotalGard (175

**Table 1** A selection of different types of mouthguard and their availability

Name	Type	Price	Contact
Masel doubleguard	Stock	£2.15 plus VAT	www.orthocare.co.uk
The TotalGard <sup>®</sup> Athletic mouthguard	Stock	£3.95 plus VAT	www.orthocare.co.uk
Shock Doctor Braces	Stock and	£11.75 inc VAT	www.hockeyfactoryshop.co.uk
Shock Doctor V1.5 – 3.0	mouth formed	From £5.88 to £23.09 inc VAT	
Grays Razor mouthguard	Mouth formed	£2.21 inc. VAT	www.hockeyfactoryshop.co.uk
Signature type I Orthodontic mouthguard	Mouth formed	From £4.30 inc. VAT	www.proline-sports.co.uk
4Braces single and double guard	Mouth formed	From £14.50 + VAT	www.dental-directory.co.uk
Rainbow mouthguards	Custom made	From £19.80 to £27.50	www.archform2000.com
Custom made mouthguard from O-PRO	Custom made-direct to public	£26.45 to £44.95	www.opro.com Info@opro.com





**Figure 3** 4Braces single arch mouthguard

Cedar Lane, Teaneck, NJ, USA) (Figure 5) which utilises natural retention from the lips and cheeks to keep it in place, and 4Braces Double Guard (Myofunctional research Co., Europe, 5144NN Waalwijk, Netherlands) (Figure 6). The Masel Doubleguard and TotalGard are made from rubber and can be trimmed to size for greater comfort. They do not require to be placed in hot water for moulding and adapting and claim to have an instant fit.

## Discussion

The performance of any mouthguard is dependant on the energy absorption of the material from which it is made, the resistance to deformation and the degree of comfort to the wearer. Testing the performance of one type of mouthguard over another remains problematic *in vivo* but a standardized laboratory technique has been developed.<sup>23</sup> Different projectiles with various energies are dropped down a plastic tube and impact a mouthguard placed on a simulated jaw. The extent of



**Figure 5** 4Braces double arch mouthguard

the damage to the teeth and jaw can then be assessed. Attempts have been made to improve mouthguard performance by increasing the thickness of the material<sup>24</sup> but this adds to its bulk. Addition of air cells have been shown to improve EVA's energy absorption and reduce transmitted forces to teeth.<sup>12</sup> Other modifications include the addition of sorbothane,<sup>25</sup> round archwire strengtheners,<sup>26</sup> an intermediate layer of sponge between EVA,<sup>27</sup> leaving a space between the tooth surface and



**Figure 4** TotalGard – multi-sport mouthguard



**Figure 6** Masel Doubleguard

inner layer of mouthguard,<sup>28</sup> and adding other layers to the EVA.<sup>29</sup>

Recommendations in the construction of custom made mouthguards include incorporating all the maxillary teeth to the distal surface of the second molars, labial extension to within 2 mm of the vestibular reflection, a rounded labial flange edge, tapered palatal edge, palatal flange extension to within 10 mm of the gingival margin and dimensional thickness of 3 mm labially, 2 mm occlusally and 1 mm palatally.<sup>14,30</sup>

At present, mouth formed mouthguards are used more widely in sporting activities than custom made mouthguards due to lower costs, convenience and ease of availability, but as *in vitro* tests in the laboratory have shown, they are not as strong and resilient as the latter. Custom made laminate mouthguards with their greater number of layers and thickness have led to greatly improved orofacial protection especially in the most vulnerable areas. As individual awareness is increased over time as to the merits of wearing a custom made mouthguard, the balance between the two mouthguards is hoped to tilt in favour of custom made mouthguards, thus reducing the incidence of oral trauma in contact sports. Future research into improved mouthguard materials and design to better absorb impact forces and thus a reduced transfer of energy to teeth, jaws and brain are the way ahead and work is on going. Also, a standardized testing regime and instrumentation is required against which new mouthguards can be tested to develop a quantifiable index of protection.<sup>14</sup>

The literature does not provide clear evidence for which type of mouthguard should be recommended for orthodontic patients with fixed appliances. Two options are potentially available depending on factors such as the patient's level of sporting participation, socio-economic background and potential compliance to wear. The ideal choice would be a custom-made mouthguard with the modifications described. A laboratory based study<sup>31</sup> investigated whether bonded maxillary casts could be protected as efficiently as non bonded casts by the same custom-made mouthguard during the same impact. It found no statistically significant difference between the tested groups. The authors concluded that the degree of protection afforded by a custom-made mouthguard on an unbonded maxillary cast was the same as that for a bonded cast and a custom-made mouthguard.

An alternative approach would be to use one of the new generation of non-customised mouthguard which incorporate an ortho-channel to accommodate a fixed appliance as well as orthodontic movement of teeth. This would cost less and require fewer changes.

However, no studies have been undertaken to date, to test the effectiveness of these mouthguards.

## Conclusion

It is recommended that all orthodontic patients wearing fixed appliances and participating in contact sports should wear a sports mouthguard to protect against the possible dangers described.<sup>16</sup>

Currently the authors would continue to recommend a custom-made mouthguard, blocking out areas on the construction cast to allow for tooth movements and dental development. Future research is required to determine whether some of the specialized mouth formed guards described in this article could offer similar levels of protection.

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