# A review of mouthguards: effectiveness, types, characteristics and indications for use

K. Parker,[1] B. Marlow,[1] N. Patel[1] and D. S. Gill*[1]

**In brief**

- Informs clinicians about risks of dental trauma during sport and the effectiveness of mouthguards.
- Details the different types of mouthguard available.
- Explains the characteristics of the different types mouthguard and the indications for their use.
- Explains possible barriers to mouthguard use.

Participation in sport carries an increased risk of sustaining dental trauma which can be reduced by the use of a mouthguard. Mouthguards work by dissipating the force of impact, thus reducing the force which is transferred to the dentition. There are different types of mouthguard available which vary in design, costs and the level of protection provided. This article aims to review the use of mouthguards in sport, the common barriers to their use and also the different types of mouthguards and their characteristics.

## Introduction

Participating in contact sports carries an increased risk of sustaining dental trauma with sporting accidents accounting for 10–39% of all dental injuries in children.[1] Other causes of dental injuries include fights, road traffic accidents and accidental damage, for example from trips and falls.[2,3] A contact sport can be defined as a sport in which players physically interact with each other, trying to prevent the opposing team or person from winning.[4] Participants of contact sports have been shown to be more prone to orofacial injuries, with dental injuries being the most common type of injury.[5]

The Oral Health Foundation advises that mouthguards should be worn at all times while participating in any contact sport.[6] Despite this advice, there are currently no UK guidelines by dental bodies specifying exactly which sports mouthguards should be worn for. This differs from American advice where the American Dental Association (ADA) have produced guidelines on which specific sports require a mouthguard (Table 1).[7]

Within the UK, mouthguards are mandatory for a limited number of sports and in a few specific sporting situations, more often their use is purely advisory or recommended. In the UK, mouthguards are compulsory for all school players participating in rugby above school level (County, Division and England Representative Squads)[8] and for lacrosse competitions in a competitive league.[9] It is also mandatory to wear a mouthguard while participating in boxing[10] and most organisations recommend the use of mouthguards for field hockey[11] and martial arts.

However, in the majority of sports mouthguard use is voluntary despite the significant risks of dental injury. A meta-analysis in 2007 evaluated the effectiveness of mouthguards in reducing dental injuries and found the overall risk of injury to be 1.6–1.9 times less when a mouthguard was worn, compared to when mouthguards were not used during athletic activities.[12] Interestingly, a recent High Court case where a hockey player, who suffered dental injuries in a match when she did not wear a mouthguard, was ruled in favour of the school.[13] The hockey player lost her negligence claim against the school where the judge ruled that the school's policy of recommending the use of mouthguards, rather than enforcing mandatory use, met the appropriate standard of care.[13]

## Mouthguards

A mouthguard is defined as 'a resilient device or appliance placed inside the mouth to reduce oral injuries, particularly to teeth and surrounding structures.'[1] They were first introduced in boxing in the 1920s and were later used in American Football due to their

**Table 1 Sports for which the ADA advise the use of a mouthguard[7]**

| | | | | |
|---|---|---|---|---|
| Acrobatics | Equestrian events | Ice hockey | Shot put | Squash |
| American football | Extreme sports | Inline skating | Skateboarding | Surfing |
| Baseball | Field events | Lacrosse | Skiing | Volleyball |
| Basketball | Field hockey | Martial arts | Skydiving | Water polo |
| Bicycling | Gymnastics | Racquetball | Soccer | Weightlifting |
| Boxing | Handball | Rugby | Softball | Wrestling |

[1]Eastman Dental Hospital, Orthodontic Department, 256 Gray's Inn Road, London, WC1X 8LD
*Correspondence to: D.S. Gill
Email: daljit.gill@nhs.net

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effectiveness at reducing oral injuries.[14,15] Mouthguards cover the teeth and some or all of the gingiva and act by dissipating forces and by reducing the deflection of teeth which are subject to stresses.[16] As well as reducing oral injuries, mouthguards act to retain any fractured or loosened teeth thus preventing their loss, inhalation or ingestion.

Historically, mouthguards were thought to also reduce concussion injuries by reducing the amount of force transmitted to the skull because they opened the bite, which caused separation of the condylar head and the glenoid fossa, which subsequently reduced the force transmitted to the skull.[17] More recently, however, it has been concluded that there is currently no evidence to suggest that mouthguards prevent concussion.[18–20]

Mouthguards are usually made from a thermoplastic material, typically ethylene vinyl acetate (EVA) due to its availability, formability and ease of manipulation.[1,21,22] As with all dental materials, there is the possibility that patients may be allergic to the materials used, however, to date, there are no published instances of mouthguard-related allergic reactions.

Custom-made mouthguards were traditionally made using a single layer technique where a traditional vacuum forming machine was used to apply a low heat and a vacuum to soften a layer of the thermoplastic material and form the mouthguard from a stone model of the patients teeth.[7] This method often resulted in insufficient thickness of the mouthguard, due to only using a single layer of material, therefore the use of a pressure lamination technique was used to overcome this.[1,7] Pressure lamination combines the use of heat and high pressure to fuse multiple layers of material together to provide a defined thickness of material.[7] This method of fabrication is generally more accurate and the mouthguards suffer less deformation than those made by vacuum forming, therefore pressure lamination is currently the preferred method of mouthguard fabrication.[1]

A properly fitting mouthguard should be protective, comfortable, resilient, tear-resistant, odourless, tasteless, inexpensive, easy to fabricate and cause limited alteration to speech.[23] Mouthguards suffer wear, especially occlusally, during use and as such it is suggested that adults replace their mouthguard approximately every one to two years. In growing children mouthguards should be replaced approximately every year to accommodate growth of the mouth, jaws and development of the adult dentition.[24] For patients undergoing orthodontic treatment, mouthguards may need to be replaced or remoulded during treatment depending on the magnitude of tooth movement.

## Types of mouthguard

There are three main types of mouthguard:

1. Pre-fabricated
2. Mouth-formed
3. Custom-made.

### 1. Pre-fabricated mouthguards

Pre-fabricated mouthguards are pre-made and are thus not fitted specifically or adapted to the patient. They come in different sizes with the patient choosing their own 'best fit' size. They are generally the cheapest type of mouthguard and are readily available from many retail outlets including sports shops, department stores and chemists. There are three types of pre-fabricated mouthguard:

- Single jaw
- Bimaxillary
- Orthoguard.

#### *Single jaw*

Single jaw mouthguards can be made for the upper or lower jaws, however, they are more commonly fabricated for the upper jaw due to the upper teeth being more susceptible to trauma. A pre-fabricated mouthguard for the upper jaw is shown in Figures 1a and 1b and their advantages and disadvantages are detailed in Table 2.

#### *Bimaxillary*

Bimaxillary mouthguards cover both the upper and lower jaws in one single appliance and thus offer protection to both the upper and lower teeth (Fig. 2).[21] Due to covering both jaws these mouthguards are more bulky and can affect speech and can be difficult to tolerate.

#### *Orthoguards*

These mouthguards have been developed to try and overcome some of the limitations of mouthguards for patients undergoing fixed appliance orthodontic treatment. They have a cut away channel on the fitting surface to accommodate the fixed appliances and any tooth movement.[21] Depending on the extent of tooth movements planned, these mouthguards may need to be changed as the orthodontic treatment progresses.

### 2. Mouth-formed mouthguards

These mouthguards are commonly referred to as 'boil-and-bite'. They are made from thermoplastic material which becomes soft and mouldable when heated.[1] The mouthguard is placed in hot water (according to the manufacturers guidelines) until the plastic becomes mouldable. It is then formed to the patient's teeth, soft tissues and occlusion

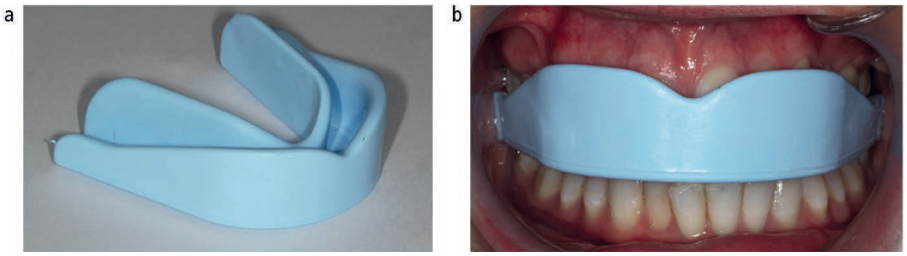


**Fig. 1 a) A pre-fabricated mouthguard; b) A pre-fabricated mouthguard *in situ***

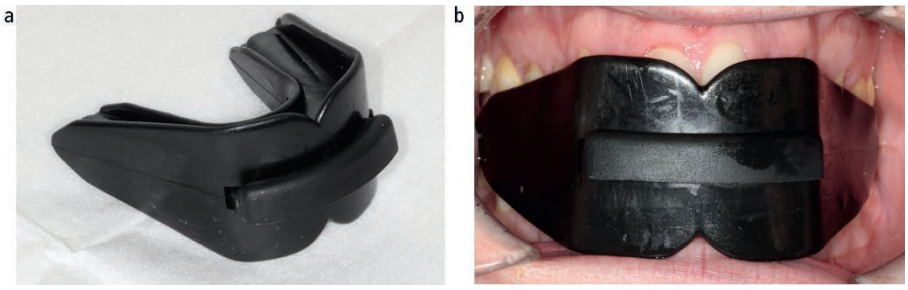


**Fig. 2 a) A pre-fabricated bimaxillary mouthguard; b) A pre-fabricated bimaxillary mouthguard *in situ***

**Table 2 The advantages and disadvantages of the different types of mouthguard**

| Type of mouthguard | Cost | Retention and fit | Protection | Contact with dentist | Other factors |
|---|---|---|---|---|---|
| Pre-fabricated | Cheap | Poor | Poor | Minimal | Readily available from retailers, not adaptable |
| Mouth-formed | Moderate | Average | Average | Minimal | Readily available from retailers, adaptable |
| Custom-made | Expensive | Good | Good | Required | Can be made to allow orthodontic tooth movement, not adaptable |
| Orthoguard | Moderate | Average | Average | Minimal | Better fit around fixed orthodontic appliances, allows movement of teeth, adaptable |
| Bimaxillary | Moderate | Average | Average | Minimal | Difficult to source, not adaptable |

by soft tissue moulding and applying firm occlusal pressure onto the softened plastic.[1] The moulding process is completed by the patient with minimal input from their dentist or orthodontist. A mouth-formed mouthguard before, during and after moulding can be seen in Figure 3.

## 3. Custom-made mouthguards

Custom-made mouthguards are fabricated by dental laboratories from dental impressions. They are usually made from polyethylene vinyl acetate (EVA) and are suitable for both orthodontic and non-orthodontic patients.[1,21] The fit of the mouthguard is checked by the dentist or orthodontist and they generally have a better fit than mouth-formed and pre-fabricated mouthguards, due to being specifically adapted to the patient. The main drawbacks of custom-made mouthguards are that they involve at least one dental appointment and they are the most expensive type available.[25] The advantages and disadvantages of custom-made mouthguards are detailed in Table 2. Similarly to pre-fabricated mouthguards, there are multiple types of custom-made mouthguard:

- Single jaw
- Bimaxillary.

### *Single jaw*

Similarly to pre-fabricated mouthguards, custom-made mouthguards can be fabricated for the upper or lower jaws and therefore provide protection to the teeth in that jaw. A custom-made mouthguard for the upper jaw can be seen in Figure 4.

### *Bimaxillary*

Again similarly to pre-fabricated mouthguards, custom-made mouthguards can be fabricated to cover both the upper and lower jaws in one appliance (Fig. 5). Custom-made bimaxillary mouthguards often incorporate holes in the anterior region to facilitate air flow during use.

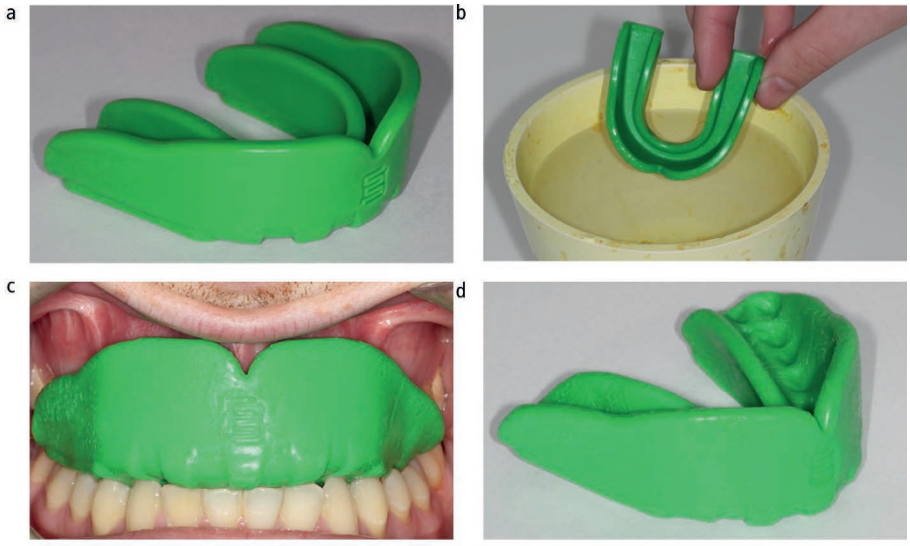


**Fig. 3 a–d) A mouth-formed mouthguard, before, during and after forming it to the patient's mouth**

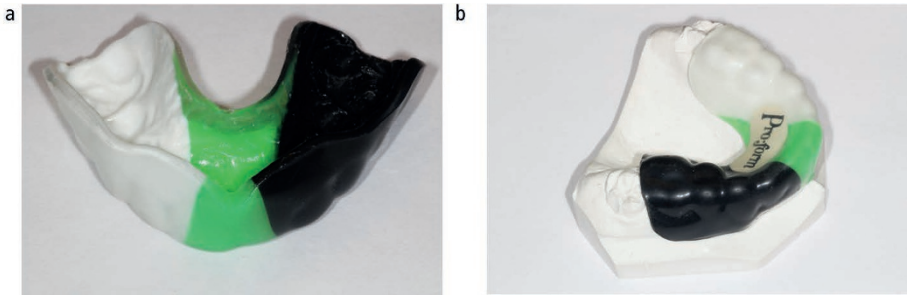


**Fig. 4 a and b) A custom-made mouthguard for the upper jaw**

## Use during treatment

Orthodontic treatment is most commonly carried out in adolescence, a peak time for sustaining dental injuries during sporting activities.[26] An increased overjet and incompetent lips can predispose patients to an increased risk of dental trauma.[27] It is important that patients undergoing orthodontic treatment wear a mouthguard while participating in contact sports. Any removable orthodontic appliances can be removed, and stored safely, during sport

**Fig. 5 A custom-made bimaxillary mouthguard**

and the patient can wear a pre-fabricated, mouth-formed or custom-made mouthguard.[21] During fixed appliance orthodontic treatment, patients can use mouth-formed mouthguards which can be moulded around the brackets and can be re-moulded as teeth move.[21,28] Alternatively, they can use orthoguards or custom-made mouthguards which can be designed to incorporate a cut out channel for the orthodontic appliance and also allow space for tooth movement.[21,28] The frequency at which the mouthguard will need to be re-moulded or remade will depend on the rate and magnitude of tooth movement and can be advised by the patient's orthodontist.

## Fabrication

Custom-made mouthguards are fabricated from stone models of the patient's teeth and intra-oral soft tissue. Alginate impressions need to be taken of the arch for which the mouthguard is to be made. These are then cast up in hard stone. The impressions must include all of the teeth and extend to include the terminal molars. It should also capture the labial fraenum, the palate and have full vestibular extension and borders.[7,21] A wax bite may also be required by the dental laboratory, in which case it is advised that the wax bite is taken with the teeth approximately 1.5 mm apart.[21]

The dental impression and the wax bite should be sent to the dental laboratory with a complete laboratory prescription detailing the type and design of the mouthguard to be made. In fabricating the mouthguard the labial flange should extend to within 2 mm of the vestibular reflection and have rounded edges and the palatal flange should extend to within 10 mm of the palatal gingival margins and have a tapered edge.[21] It is advised that mouthguards have a thickness of 4 mm occlusally, 3 mm labially and 1 mm palatally.[21,29] If any orthodontic tooth movements are to be undertaken the laboratory should be informed of the proposed movements so that the mouthguard can be fabricated to accommodate these. Depending on the extent of the tooth movement, the mouthguard may need to be remade as treatment progresses.

## Adjustment of mouthguards

If a mouthguard is over extended it can be adjusted by the clinician or the laboratory. The flanges can be reduced to their correct extension and correct fit. If a mouthguard is under extended it is important that new, fully extended, impressions are taken so that a new mouthguard can be made with fully extended flanges.

## Mouthguard care

It is important that mouthguards are cared for properly to ensure their longevity and continued effectiveness. Before and after use mouthguards should be rinsed in cold water. Hot or warm water should not be used because this can cause distortion. A small toothbrush and water, with or without toothpaste can be used to clean mouthguards to maintain freshness. When not being worn, mouthguards should be stored in a secure container to prevent loss or damage and they should be kept away from heat and direct sunlight to prevent distortion. Mouthguards should be regularly checked by the patient's dentist or orthodontist and they can advise when they need replacing.

## Discussion

The different types of mouthguard offer differing levels of fit and protection. Custom-made mouthguards are generally considered the most superior, offering the highest level of protection.[1] Pre-fabricated and mouth-formed mouthguards generally have a poorer fit and are less retentive than custom-made mouthguards. Pre-fabricated mouthguards have been described as being loose by 42% of athletes when compared to custom-made mouthguards.[1,30] When mouthguards lack retention, athletes often have to exert occlusal forces to keep them in place and they can therefore easily be dislodged during use.[1,21] Articulation between team members subsequently becomes difficult often leading to players preferring to remove an ill-fitting mouthguard thus increasing their risk of dental injury.[21]

One of the disadvantages of any mouthguard which is not custom-made is that they can be of insufficient length. Kuebker and Morrow (1986) found that only 15% of mouth-formed mouthguards covered the terminal molars of high school and college athletes.[31] These undersized mouthguards provided less protection than suitably adapted custom-made ones with the terminal teeth having an increased risk of trauma.[31,32]

The optimal thickness of mouthguards is important. If mouthguards are too thick they can be hard to tolerate and if they are too thin their protective abilities are compromised.[1,29] Reducing the thickness of a mouthguard has a substantial effect on its protective capability; as the thickness of the material reduces, the transmitted force of the impact increases logarithmically.[31] During the moulding process of mouth-formed mouthguards, the thickness of the material can be reduced by as much as 99% occlusally, drastically reducing its protective capabilities.[29] Thicker mouthguards therefore offer greater protection but are less comfortable. Studies examining the protective capabilities of mouthguards have found the optimal thickness to be 4 mm.[29] This optimal thickness can only be ensured when a mouthguard is custom-made.

Custom-made mouthguards have the advantage of being designed and fitted by the dentist or orthodontist and therefore, the fit, retention, thickness and extension of the mouthguard can be checked before issuing it to the patient. Due to their improved fit they allow athletes to breathe and speak more easily and generally have increased comfort levels.[30,33] With all of their benefits, custom-made mouthguards still require replacing every two years because their fit and retention can reduce over time.[33] Patients should be aware that once the biting surface has flattened, or should the front teeth wear through the guard, its protective properties will have been diminished. Although custom-made mouthguards have the added benefit of allowing for prescribed orthodontic tooth movement they may still have to be remade during treatment depending on growth of the patient and the magnitude of tooth movement.

Overall, research has shown that custom-made mouthguards offer a superior fit and protection compared to the other types of mouthguard which are not custom-made.[1,30,33]

## Mouthguard wear

Athletes often do not wear mouthguards despite being aware of their protective capabilities and there being widely available literature advising their use.[1] Even after having sustained previous oral-facial injuries, athletes have still been found to have poor compliance with mouthguard wear.[35]

Athletes who routinely wear mouthguards may not be aware of which type offers the best protection. A study investigating mouthguard wear in American football players, where mouthguard use is compulsory, found that 33% of athletes wore custom-made mouthguards, 33% used both custom-made and mouth-formed and 27% used mouth-formed only, despite custom-made mouthguards offering the best protection.[36]

## Barriers to mouthguard wear

To improve mouthguard wear it is important to identify the barriers to their use. Several factors have been identified as barriers to mouthguard wear:[1,36]

- Poor retention
- Intra-oral dryness
- Nausea
- Interference with breathing
- Interference with speaking
- Athletes priding themselves on not wearing a mouthguard
- Increased cost of custom-made mouthguards
- Custom-made mouthguards requiring dental appointments.

Where children are concerned, it is often the parents who arrange the provision of a mouthguard and decide if and when one should be worn. To increase mouthguard wear in children it is therefore necessary to educate parents about the necessity and the benefits of mouthguard use.[37] A recent audit carried out at the Eastman Dental Hospital found that in 95% of cases where mouthguards were not worn for contact sports, the main barrier to use was a lack of awareness of their need.[38]

It is also possible that dentists may not know which type of mouthguard to recommend to their patients, resulting in suboptimal protection and poor compliance. To ensure maximum protection, when taking impressions for custom-made mouthguards dentists should be aware of the importance of capturing the full functional depth of the sulcus and the most terminal molars.[21]

## Recommendations

Clinicians should routinely ask their patients, within their social history, about any sports they participate in and if patients do participate in sports they should recommend the use of a mouthguard. Advocacy for mouthguard use should also focus on sports coaches, sporting organisations and governing bodies. Coaches and teachers should be encouraged to insist on players wearing mouthguards for training as well as matches, even if the rules of the game do not stipulate their mandatory use. Within the UK it may be advisable to adopt an approach similar to that used in America where mouthguards are more routinely worn and wear is required across a larger number of sports.


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