

The dentist's role in the prevention of sports-related oro-facial injuries

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Introduction

Many patients present requesting aesthetic dental treatment in order to rectify the sequelae of dental injuries received whilst playing sport (Figure 1). While most dentists are therefore indirectly involved in the treatment of sports-related dental injuries far fewer become actively involved in the prevention of such injuries.

The role of the sports dentist

Participation in exercise and sport is a major consideration in the health of a national population and one that will likely continue to grow. A 1990 report published by the Centre for Health Promotion and Research entitled: 'Sports injuries in Australia, Causes, Costs and Prevention' estimated that, at the time of the report, sports injuries cost Australia (population 18 Million) about \$1.4 billion per year and that between 30-50% of these injuries were preventable. As will be discussed later, a large proportion of these injuries involve teeth and the surrounding soft and hard tissues and therefore as dentists we are well-placed to guide and advise participants in sport. Sports dentistry is far more than just the provision of mouthguards and should include the diagnosis of dental disease and pathologies that could impact upon the athlete (Chapman 1989). Poor dental health can limit an athlete's ability to train and compete at their very best and acute dental conditions such as pulpal, periodontal and mucosal inflammation and, in particular, pericoronitis regularly can and do force athletes either to withdraw from a competition or perform at a reduced level.

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Figure 1: Sports-related dental injuries are usually permanent, disfiguring and involve a lifetime of maintenance.

This is especially the case in so-called 'elite' athletes for whom sport is either their main source of income or plays a significant role in their everyday lives. According to a paper published by the International Olympic Committee in 2000 it would appear, however, that the sporting community has often ignored the role that dentistry and oral health may play in allowing athletes to compete at their optimal level. The authors concluded that 'It is our firm belief that many athletes are unable to maintain proper dental health due to financial restrictions, availability or both. This is reflected in the tremendous demand for dental care of a non-urgent nature at Olympic Games and other major championships.' Specific concerns were oral cancer caused by chewing tobacco, a habit that is popular with many athletes, dental caries resulting from sport drinks, wisdom teeth making jaws of young athletes more susceptible to fracture during competition and last but not least the role of mouthguards in reducing brain concussions by absorbing harmful forces.

Of these, tobacco chewing is not particularly popular in the UK, or at least not in a sporting context and of much greater significance to UK athletes is the risk posed by the



Figure 2: Increased overjets increase the likelihood of dental injury.

excessive use of potentially harmful (to teeth) sports drinks (Tahmassebi 2004). Research conducted by Mintel in 2005 noted that the consumer's quest for a healthier lifestyle continues to drive demand for sports drinks and supplements and accordingly, sports drink sales are expected to grow across all age groups.

The risk of injury playing sport

It has long been known that participation in sports carries a considerable risk of sustaining dental injury (Davies and Bradley 1977, Sane and Ylipaavalnimei 1988, Rodd and Chesham 1997). In a 10 year review of over 21,000 cranio-maxillofacial injuries seen at an Austrian OMFS clinic 31% were sports-related (Gassner 2003). Contact sports are defined as those sports in which players physically interact with each other, trying to prevent the opposing team or person from winning (Dorney, 1998). A considerable number of papers have appeared in the dental literature highlighting the dangers of participation in such sporting activities, in particular 'stick' sports such as lacrosse, and field and ice hockey (Bolhuis 1987, Sane and Ylipaavalnimei 1988). In addition, competitive matches have been shown to be far more hazardous than training sessions, Sane and Ylipaavalnimei (1988) found that 69% of all injuries occurred during matches, compared with 31% during training sessions. This latter paper presents data that have been tested for significance, unlike a number of other studies, which have been subjective in nature and presented data not tested for significance.

The ongoing prevalence of injuries in certain contact sports, such as rugby football (Clegg 1969, Morton and



Figure 3: So-called 'boil and bite' mouthguards are widely available and inexpensive but are seldom provide adequate protection, are usually unretentive and uncomfortable and can give the athlete a false sense of security.

Burton 1979, Sugarman 1983, Chapman 1985a, 1991, Chapman and Nasser 1996, Quarrie 2005) and ice hockey (Biasca 2002) has been consistently reported in the dental literature. It has been estimated that players of such sports have a 10% chance per playing season of sustaining an injury and up to a 50% chance of injury in their playing career (Clegg 1969, Heintz 1968) Historically, baseball has the greatest number of fatalities in sport for 5–14 year-olds in the US. There were 51 deaths between 1973 and 1983 (Padilla and Balikov, 1993), 15% of which were caused by a blow from a ball hitting a body part other than the chest. Of the 280,652 baseball injuries reported over a period of one year by the US Consumer Product Safety Commission's 1990 report, 41% involved head, face, mouth and eyes (Padilla, 1993). The incidence of dental trauma in other sporting activities, widely perceived to carry a lower risk of dental injury, is also well-documented, for example football (Finch 2005), squash (Persic 2006), basketball (Maestrello-de Moya M and Primrosch 1989, Labella 2002), handball (Lang 2002) and alpine skiing (Gassner, 2000).

Although the incidence of dental trauma compared with all accidents in contact team sports is seldom very high, varying from 2% to 33% (Roas and Nilsson 1979, Pritchett 1981, National Health and Medical Research Council 1994), the related costs are both high and disproportionate to the number of accidents. A report by the US-based National Youth Sports Foundation for the Prevention of Athletic Injury Inc. (1992), highlighting the cost of repairing damage caused by sports-related oral facial injuries, showed that victims of total tooth avulsions whose teeth are not properly preserved or replanted may



Figure 4: Custom-made mouthguards made from a single layer of ethyl vinyl acetate (EVA) are often extremely thin over the incisal edges as in this case where the teeth have actually bitten through the material that is supposed to be protecting them.



Figure 5: Vacuum forming is incapable of bonding layers of EVA together and mouthguards thus formed will often delaminate.

face lifetime dental costs of US\$10,000–15,000 per tooth, many hours in the dental chair, and may develop other dental problems such as periodontal disease. Similarly, it has been shown that the treatment of maxillofacial and dental injuries account for over 13% of the costs of all football injuries (Sane and Ylipaavalnimei 1988)

An almost universal finding is that the majority of injuries affect the upper jaw, with the maxillary incisors being most prone to injury, often accounting for as many as 80% of all cases (Hedegard and Stalhane 1973, Davis and Knott 1984, Cavalleri and Zerman 1995). Highly significant differences have been shown to exist between the number of teeth injured and the causes of injury (Sane and Ylipaavalnimei 1988). For example, a blow or kick from another player most often causes injury to one tooth, while a fall or blow from a hard object often results in injury to two teeth. In addition to the damage caused by a traumatic impact to the dento-alveolar structures, damage can also result in facial bone fracture and more seriously, neck or brain injury resulting from increased cranial pressure and deformation (Hickey and Morris 1967). With the most common cause of concussion in sport being a blow to the mandible (Chapman 1985b), it has also been shown that an athlete who has sustained a concussion is four times more likely to suffer a further concussion in the future (Gerberich and Priest 1983).

In children, sports accidents reportedly account for 10–39% of all dental injuries (Gelbier 1967, Jarvinen 1980, Uji and Teramoto 1988) and often involve teeth with incomplete root formation (Andreasen and Ravn 1972). Boys are more likely than girls to incur injuries; at a ratio of 1.5–3.1 (Rothman 1996), the highest incidence occurs between the ages of eight and 11 (Rodd, 1997, Petti and Tarsitani 1996, Borsen and Holm 1997). Dental trauma has been found to be more prevalent among children with an incisal overjet greater than 7mm (Figure 2), insufficient lip

closure or both (Sgan-Cohen 2005). Adding significance to these figures is the finding that school teachers often have inadequate knowledge of how to deal with such dental injuries when they do occur (Chan 1999)

The role of the mouthguard in preventing injury

While the overwhelming majority of studies stress the significant protective values of mouthguards (Morton 1979, Chapman 1985a, Chapman 1991, Heinz 1968, Maestrello-de Moya and Primrosch 1989, de Wet 1980, Seals and Morrow 1985, Garon 1986, Kerr 1986, McNutt 1989, Lee-Knight and Faulkner 1991, Flanders and Bhat 1995), one study (Blignault 1987) could find no statistically significant differences between rugby players who wear mouthguards and those who do not with respect to head and neck injuries in general, and to oral injuries in particular.

Mouthguards were first introduced by Woolf Krause, a London dentist as a means of protecting boxers from lip lacerations (Reed 1994). The technique soon made its way to the US and by the 1920s and 1930s mouthguards were part of a boxer's standard equipment and were later adopted by gridiron footballers, primarily as a result of the pioneering work of a number of American dentists including Cohen and Borish (1958) and Cathcart (1958) the former demonstrating that, 'the wearing of a properly fitted mouthguard all but eliminated mouth injuries in high-school footballers'. In 1962, the use of mouthguards became mandatory in US high-school football and in 1974, the same rule was introduced at college level. This proved to be an extremely far-sighted piece of legislation. Heintz 1968 reported that of the two million people participating in the sport in the US, the mandatory use of mouth protectors had cut the injury rate to the face and mouth from 50% of all injuries to $\geq 0.5\%$.

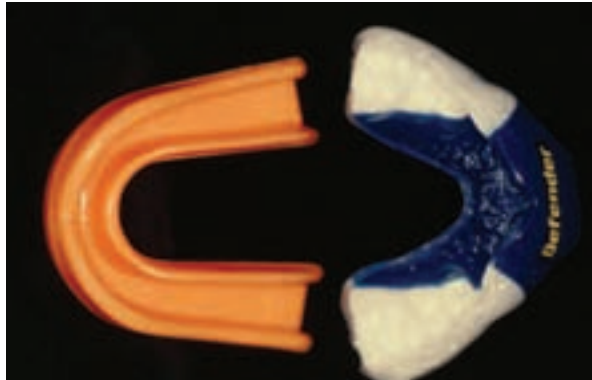
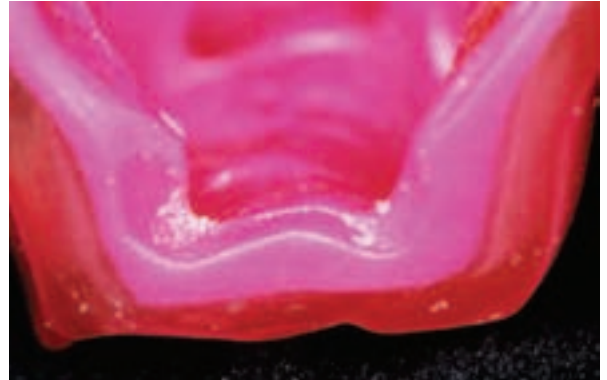


Figure 6a, b, and c: Laminated mouthguards made with high pressure forming machines offer the best protection against injury, especially compared to shop-bought 'boil and bite' varieties (6a)



Several studies suggest that mouthguards are not just effective in the prevention of dento-alveolar injuries – for example, Stenger (1977) demonstrated the relationship between mouthguards and decreased incidence of concussion. This led Chapman (1985a) to suggest that, 'the use of mouthguards should be encouraged in all contact sports, as the most important value of the mouthguard is the concussion-saving effect following impact to the mandible. This fact alone should make the wearing of mouthguards compulsory in all contact sports.' In addition, Hickey and Morris (1967) found in their work on cadavers that mouthguards reduced the intracranial pressure and hence the force of impact to the brain arising as a result of a blow to the chin. The authors postulated that this effect is most likely achieved by increasing the space between the head of the condyle and the mandibular fossa of the cranium. These various claims have however been, refuted recently by (McCrory 1999) who described a number of methodological concerns with Hickey's study and concluded that the ability of mouthguards to protect against head and spinal injuries falls into the realm of 'neuromyology' rather than hard science.

The question remains of what constitutes a 'properly fitted', i.e. satisfactory, mouthguard? Heintz's paper (1968), as with many that appear in the literature, fails to distinguish the different types of mouthguard and it is therefore often difficult to establish their relative efficiencies. The term 'mouthguard' is universal and generic and includes a large range and variety of products, from over-the-counter models bought at sporting goods stores to professionally manufactured and dentist-prescribed custom-made mouthguards.

It is clear that mouthguards, just like the athletes they are designed to protect, are not the same. This was graphically illustrated in a study of 2470 American footballers (Lee-

Knight and Faulkner 1991) which found that while 53 athletes were injured while not wearing a mouthguard, a further 53 were injured, reportedly while being 'protected' by a mouthguard. The mouthguards referred to in this study were of various types, with some likely to offer greater protection than others and clearly, such a high injury rate calls into doubt the effectiveness of many mouthguards.

Types of mouthguard

The mouthguard (also referred to as a gumshield or mouth protector) is defined as a resilient device or appliance placed inside the mouth to reduce oral injuries, particularly to teeth and surrounding structures. Mouthguards are effective because they considerably diminish the deflection of teeth subjected to stress in comparison with unprotected teeth (Hoffmann 1999). Theoretically, a properly fitted mouthguard should be protective, comfortable, resilient, tear-resistant, odourless, tasteless, inexpensive, easy to fabricate and should not interfere with speech (Scott 1994). The most common types of mouthguard available to athletes comprise:

Type I: stock mouthguards, bought over-the-counter and designed to be used without further modification, such mouthguards are no longer widely available;

Type II: mouth-formed boil-and-bite mouthguards. Also available commercially, they are made from a thermoplastic

material that is immersed in hot water and then formed in the mouth by the athlete using finger, tongue and biting pressure;

Type III: custom-made on a model of the patient's mouth.

A variety of materials are currently being used for mouthguards, most commonly polyvinyl-acetate-polyethylene copolymer and polyvinyl chloride. Silicone rubber, natural rubber, soft acrylic resin, and polyurethane are less widely used (Auroy 1996)

Both the stock and boil-and-bite mouthguards are bulky and lack proper retention (Figure 3) requiring them to be held in place by constant occlusal pressure. In one study a loose fit with this type of mouthguard was noted by 42% of athletes compared to none for the custom-made type (Deyoung 1994) This study also showed that more difficulty was noted by athletes while wearing self-adapted mouthguards. As Chapman (1996) points out, any mouthguard which requires the teeth to be clenched to hold it in position is unsatisfactory and unsafe. As well as deficiencies in retention, arch-length studies have shown that the largest available mouth-formed mouthguards, even if used properly, would only cover posterior teeth in 15% of high school and collegiate athletes (Kuebker and Morrow 1986).

Further evidence of the deficiencies of self-adapted mouthguards comes from Park (1994) who showed that during the moulding process, the occlusal thickness dramatically decreases (as much as 99%). This results in athletes biting through the mouthguard during moulding, thus taking away the protective properties of the mouthguard by excessively thinning the mouthguard occlusally and providing a false sense of protection. The authors were of the opinion that, 'unless dramatic improvements are made they should not be promoted to parents as they are now'. These ill-fitting mouthguards are clearly the least acceptable for injury prevention and athletes will often take it upon themselves to cut and modify this type of mouthguard because of poor fit and discomfort. By cutting and altering these stock and boil-and-bite mouthguards, athletes are increasing their chance of injury and concussion.

The professionally-fitted custom-made mouthguard is widely seen to give the dentist the critical capability to address several important issues in the fitting of the mouthguard, such as the appropriateness of the design for the sport being played, any history of previous dental injury or concussion, additional protection in any specific area etc. These are important considerations that the sporting-goods store retailer and the boil-and-bite mouthguard cannot begin to address. Custom-made mouthguards, usually made from a polyvinyl-acetate-ethylene copolymer (EVA), formed on a model of the athlete's upper jaw and fitted by a dentist, are widely viewed

in the literature as being more satisfactory in all aspects than any of the over-the-counter types currently available.

Type III mouthguards have traditionally been made using vacuum moulding. Although the fit of these mouthguards is adequate at the time of fabrication and injury and concussion rates are significantly decreased as compared to stock and boil-and-bite mouthguards, deficiencies have been noticed in the physical properties and thickness of EVA materials because of the methods of fabrication employed. It has also been demonstrated that when a vacuum machine is used, the EVA material stretches unevenly over the model and the incisal edges become dangerously thin (Figure 4) Shrinkage of 25% occlusally and 50% labially and lingually have also been reported (Park 1994) Protective thickness is important because as the thickness of the mouthguard material increases logarithmically, the transmitted impact force decreases logarithmically (Park 1994). Until recently however, vacuum-fabricated mouthguards had been the standard care for protective mouthguards. In addition, efficient and complete lamination cannot be achieved under low heat and vacuum (Figure 5).

The deficiencies of the single-layer vacuum-formed design have been overcome by the use of lamination, i.e. the layering of materials to achieve a defined thickness under a high heat and pressure environment (Figure 6a, b and c). The layers will not properly fuse together with the vacuum machine, but will chemically fuse under high heat and pressure (Padilla and Lee 1999) In addition, Hunter (1988) states that pressure-lamination has other advantages, i.e. as precise adaptation and negligible deformation. The combination of the relatively high heat and pressure used in construction of the laminated mouthguard means that the mouthguard has virtually no elastic memory.

Despite the widely promoted advantages of the custom-made mouthguard over the self-adapted variety, only a small number of studies have compared both types directly. Upson (1985) compared a laboratory made EVA mouthguard with an intra-orally formed relined shell type in a group of rugby players. Another study (Bass 1989) involved 10 male students wearing boil-and-bite and custom-made mouthguards for one week each. Stokes (1987) evaluated both types of mouthguard on 36 male and 12 female subjects. Deyoung (1994) examined comfort and wearability factors of the two types of mouthguard amongst 40 high-school athletes. All of these studies came to the same conclusion: custom-made mouthguards fit better, allow the athlete to breathe and speak more easily and are more comfortable. Conclusions regarding the level of protection offered were more guarded because of the short duration of the studies and relatively small sample numbers. Conformation to agreed

specifications is increasingly an issue for laboratories producing custom-made mouthguards; within Europe mouthguards are registered as personal protective equipment and must be CE marked by their manufacturer to certify that they are fit for use as protective equipment (Chadwick and Millett 1995). All dentists having mouthguards made must ensure that the mouthguard has been marked appropriately by the laboratory.

Behavioural aspects of mouthguard wear

The results are mixed with respect to the take up rate of each type of mouthguard and seem to depend on the sport being played. A study of US college football (Ranalli and Lancaster 1995a) in which mouthguard wear is compulsory, found that 33% of athletes studied reported using custom-made mouthguards, 33% both custom-made and boil-and-bite, and 27% only boil-and-bite. Chapman's study (1991) of the 1990 Australian rugby union team found that 89% of the squad wore mouthguards professionally fitted by a dentist. A study of players of international field hockey (Bolhuis 1987) where mouthguard wear is not compulsory, found that only 43% said that they were using a mouthguard at the time of the study, with over 50% stating that they had never worn a mouthguard. A survey of high-school basketball players (Maestrello-de Moya and Primrosch 1989) revealed that only 4% of players reported wearing a mouthguard, despite the fact that 31% of players sustained oral-facial injuries in one season alone.

Given the clear ability of mouthguards to prevent oral-facial injury, it is perhaps surprising to find that uptake has been rather poor. It has been shown that there is a tendency for the general public to dismiss health and safety messages, no matter how overwhelming the evidence, as individuals tend to believe the risks apply only to others (Newsom 1985). One such example is the US National Safety Council's campaign to encourage the use of seatbelts in cars. Despite statistics that seatbelt use would save 8 000–10 000 lives each year and reduce serious injuries by one-third, the campaign met with only limited success. Only in those states with mandatory laws that impose fines for noncompliance has seatbelt use significantly increased (Cutlip 2000). The same is true for mouthguard wear. Although it may be the case that there is a widespread belief among athletes that mouthguards are effective in preventing oral-facial injury, e.g. 96.7% of the 1990 Australian Rugby Union squad (Chapman 1991), this belief may not necessarily be translated into mouthguard-wearing behaviour. This

phenomenon is not of course restricted to the wearing of mouthguards. A large number of studies have found little correlation between a person's reported attitude towards something and his or her actual behaviour towards it. For example, La Piere's study (1934) on attitudes towards ethnic groups showed that many participants who might be identified as racially prejudiced from their verbal statements, nevertheless behave positively, or at least politely, towards individual members of another ethnic group in recorded situations.

It is now widely accepted that behaviour is determined by many factors other than attitudes and that these factors affect attitude-behaviour consistency. The Theory of Reasoned Action, as proposed by Fishbein and Ajzen (1975) acknowledges the power of other people in influencing one's behaviour. In the case of mouthguard wear, it is what the athlete believes other people think he or she should do with respect to wearing mouthguards. This belief is known as the 'subjective norm', the value of which is arrived at by including two other factors. Firstly, the intensity of a normative belief that others believe an action (wearing a mouthguard) should be taken or not taken, and secondly, the motivation to comply with that belief (i.e. the degree to which the person takes others' anticipated reactions into account when evaluating a course of action). Peer pressure plays an enormous role in team sport behaviour and it is perhaps not surprising that people may not wear mouthguards, even if they think they are beneficial, if there is a team ethos or 'code of conduct' of not wearing a mouthguard.

As previously described, the sport of American football mandates that mouthguards be worn at both school and college levels; NCAA football rule 1-4-4 states that mouthguards must be worn in both practice and games. Unfortunately, rules do not guarantee compliance and while officials are empowered to enforce mouthguard regulations, it is clear that the risk of penalties has less influence on players' behaviour than other factors (Ranalli and Lancaster 1995b). Some of these factors may be the social pressures described above, perhaps combined with beliefs about the mouthguard itself. It has been found, for example, that football quarterbacks pride themselves on not having to wear a mouthguard and often complain that the mouthguard itself interferes with breathing and the ability to call signals (Morrow and Kuebker 1984). It is no coincidence then that the quarterback is the player least likely to wear a mouthguard and, incidentally, is also the most likely to suffer a concussion (Padilla 1996). Finally, it must be appreciated that where children are concerned it

is the parents who often decide whether mouthguards are worn or not and it is therefore necessary to influence them and perhaps overcome various existing beliefs and prejudices (Diab and Mourino 1997)

Conclusion

It is clear that the literature views mouthguards as offering considerable protection against sports-related dental injuries. Equally it is clear that although custom-made mouthguards are seen to offer better protection than the 'boil-and-bite' type, many people do not use them because they are perceived to be expensive and necessitate a visit to the dentist. Further research is required to assess the relative protection afforded by the various types of mouthguards currently available. There is growing opinion that while much progress has been made in the use of mouthguards, the profession could do much more to promote their use. This can be at an individual level within the dental practice setting or more widely by targeting governing bodies, coaches and schools (Holmes 2000) and also by finding ways to make mouthguards more affordable to the public.

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