Evidence-based Review of Prevention of Dental Injuries

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Abstract

Despite efforts in reducing the number of dental traumas, most current studies indicate that the incidence of dental trauma remains unchanged and is at a relatively high level for children and young adults. When reviewing the literature on prevention, it is clear that until now the main focus has been on making and promoting mouthguards. The majority of the published studies on mouthguards have focused on materials used and how those behave and protect in vivo. The few epidemiologic studies that have been published on the possible protectiveness of the mouthguards in vivo are mostly of low level of evidence, and even those studies do not all agree on how much they actually protect the dentition. To compound the problem is the fact that the proportional ratio of dental trauma in organized sports is low compared with injuries that occur during children’s play or leisure activities. It could be argued that the best strategic measure for preventing dental and oral injuries is education on both how to avoid them and what to do if an injury occurs. The demand of evidence-based dentistry and medicine calls for large prospective studies with randomized intervention to investigate the actual protection of mouthguards and faceguards. In addition, more emphasis should be placed on which is the best and most constructive way to educate youngsters and teenagers on how to avoid traumatic injuries to their teeth by using contemporary means like the Internet and apps. (J Endod 2013;39:588–593)

Key Words

Dental trauma, education, faceguard, mouthguard, prevention, review

Historic Review

According to Reed (1), the first known attempt to make a device specifically to protect the oral structures in organized sports was done in the 1890s when a London dentist named Woolf Krause put together strips of gutta-percha and attached them on the maxillary teeth of a boxer. The main purpose of those gutta-percha strips appears to have been to protect the boxer from lip lacerations and other soft tissue injuries rather than actual dental injuries. Some years later or in the early 1910s, a boxer was reported to use a reusable mouthpiece that was designed by a dentist named Philip Krause, who was the son of Dr. W. Krause (2, 3). Young Krause was not only a dentist but also a keen amateur boxer himself. He apparently further developed the “gum shield” to something that approaches what is known today as a mouthguard. He used vella rubber rather than the relatively hard gutta-percha to create his mouthguards (1, 4). This new device was not widely used initially, and there was even some resistance against allowing boxers to use a mouthguard in official bouts. It is notable that in 1928 the New York State Athletic Commission was the first in the United States to allow boxers to use a “tooth protector” in fights (3, 5). Subsequently, a few articles appeared in the dental literature on how to make mouthguards for boxers by using impressions, wax, and rubber and even adding steel springs to reinforce them (3).

Boxers seem to have been the only athletic group that was concerned about their dentition early in the last century because it is not until after World War II that a few published articles started to discuss the apparent high rate of dental injuries in American football (6–8). In the following years, anecdotal reports started to appear in the dental literature that indicated benefits of mouthguards in prevention of dental injuries of high school football players (9). In the early 1960s, rules regarding headgear and mouthguards were implemented in the United States for all high school football players, and subsequently, it has been stated that facial and dental injuries sustained on the field have dropped by 48%. Unfortunately, there was never any study published that confirmed this apparent drop (10). It is hard to attribute this apparent drop of injuries only to the use of mouthguards because about the same time, better helmets and faceguard were introduced as well as stricter contact rules that all were implemented. Ten years later the National Collegiate Athletic Association (NCAA) implemented similar rules regarding mouthguards for football players and subsequently has required mouthguards for all players participating in ice and field hockey and lacrosse, unfortunately without much assessment of effectiveness of those.

Protection Devices Available Today: Do They Protect the Athlete?

Mouthguard

Oral and Dental Injuries. In reviewing the literature it becomes quickly clear that the bulk of published research on mouthguards focuses on the physical properties of various materials used to make the guard rather than true effectiveness of protection in vivo (3). Almost all of the studies evaluating the protective effectiveness of wearing a mouthguard in vivo are of very low scientific rigor; most are case reports or case series and are retrospective surveys or questionnaires in which the study design relies on the athlete or trainer/coach to recall injuries and use of protection.

There are a few studies that have attempted to investigate, prospectively or in real time, whether athletes who are wearing mouthguards sustain significantly fewer and/or
less severe dental injuries compared with those who do not (11–16). Unfortunately, most of those studies have only few numbers of athletes included, usually only low hundreds of athletic exposures (an athletic exposure is 1 athlete participating in a game or practice, whether it was 1 play, 1 quarter, 1 half, or the entire game). There are notably 2 exceptions to this (11, 14). In 2002 Labela et al (11) reported in a prospective cohort study on NCAA Division 1 men’s basketball teams. Trainers reported information about their teams on a weekly basis by using an interactive Web site. The study captured 70,936 athlete exposures. The study found that mouthguard users had significantly lower rates of dental injuries and dentist referrals than nonusers. However, there was no significant difference between mouthguard users and nonusers in the rate of soft tissue injuries. Of note is that this study reported significantly more oral/dental injuries than was reported by the NCAA for the same season. The discrepancy is possibly explained by the fact the study reminded the trainers to report weekly, whereas the NCAA only reminded them once before the season, and their reporting system was traditional paper-and-pencil report that had to be mailed versus an interactive Web site entry in the study (11).

Marshall et al (14) reported in 2005 in another prospective cohort study on roughly 12,250 athletic exposures in New Zealand rugby. The athletes were followed by weekly phone contact during the season. Their study appeared to indicate that the mouthguard lowered the risk of orofacial injury; however, no statistical evaluation was possible in this study because it only captured 2 dental injuries.

Not all studies have demonstrated a beneficial effect of mouthguards. For example, in a cross-sectional study, a sample of 321 university rugby players, no statistically significant association between oral, dental, and lip injuries sustained during play was noted with the use or nonuse of mouthguards (15).

A recent systematic review of mouthguards in sport activities concluded that studies before 1980 exhibited relatively low methodological quality and were of little or no value; a few more recent studies were of slightly higher quality (5). The authors struggled with doing a meta-analysis on those articles that they deemed to be of some quality because there was such a difference of methodological approaches and almost total lack of intervention studies. In an attempt to make unbiased comparison between the selected studies, a scoring instrument was developed to evaluate the methodology of each study, which gave the studies a score from 0–100. The score was based on rating 22 different issues from problems with definition and sample size to study designs and methodology to statistical analysis and presentation of data. The average score of 6 independent reviewers was calculated and reported for each article. Of the 14 studies included in the analysis only 3 scored 50 or above, yet they concluded that the risk of an orofacial sports injury was 1.6–1.9 times higher when a mouthguard was not worn (3). In this context it is interesting to read a Letter to the Editor that Andreassen et al (17) wrote recently regarding what they deemed to be inappropriate use of meta-analysis in an evidence-based assessment for replanted avulsed teeth. Their concerns focused mainly on the fact that in an attempt to do meta-analysis, authors are tempted to use poor studies because of the lack of quality studies. Specifically they state: “For a meta-analysis to be valid, several factors need to be considered. The meta-analysis has to be a part of a systematic review. We mean here a collection of all relevant evidence based on pre-specified eligibility criteria. The systematic review should aim at minimizing the risk of bias by using a protocol and transparent systematic method.”

Another issue is that any conclusion drawn based on reviews and meta-analyses are only as valid as the included studies. If there is a high risk of bias in the included studies, there is also a high risk of bias in the summation of the studies and the meta-analysis,” and they stress the fact that for a meta-analysis to be meaningful, non-randomized studies should not be used because it has been shown that nonrandomized studies are very prone to bias (17, 18).

**Brain Injuries.** Another suggested benefit of wearing a mouthguard is protection against brain injury or cerebral concussion. It is safe to state that there has been, and still is, a rather heated controversy among sports dentists as to whether the use of mouthguards can reduce the incidence of brain concussions, and literature is limited and divided (19–22).

Those who advocate this beneficial effect of mouthguard almost always cite 2 articles published in 1964 and 1967. Stenger et al (25) at Notre Dame wrote the former article. That article reports on 5 football players who had a history of head and/or neck injuries. Three of those players had a history of “being concussion prone,” and one had previous neck injury. The fifth athlete experienced “definite pain,” with crepitation on the left side when the temporomandibular joint was palpitated and cervical pain extending halfway down his shoulder. Subsequently, each athlete was given a custom-fitted mouthguard to use when playing football in conjunction with daily intermaxillary acrylic splint therapy. Each player’s symptoms were either eliminated or diminished. The author concluded that the custom-fitted mouthguard provided protection and relief for patients without any further investigation or reporting. Of note is that no statistics, control, or any other scientific approaches were used in this article. The second article was written by Hickey et al (24) and is a report on an *in vitro* study in which series of impact blows under the chin were applied on a single cadaver. Intracranial pressure transducer was used to measure pressure changes associated with the blows. The authors concluded “there was a decided reduction in the amplitude of the intracranial pressure wave when the mouth protector was in place. Bone deformation was also decreased moderately when the mouth protectors were in place” (24). The issue with this report is that the correlation between those factors and cerebral concussion is not at all clear (25, 26).

With a careful scrutiny of scientific evidence in the literature, the claim of brain protectiveness of the mouthguard has been further called into question (4). Two recent and very large studies that used interactive Web site to collect weekly information on incidence of cerebral brain concussion in athletes have failed to show any benefits of the mouthguard (11, 27). In the former, a comparison was made between those who wore a mouthguard and those who did not in United States college men’s basketball. Almost 71,000 athletic exposures were reported; there was no significant difference in the rate of brain concussion between the 2 groups, while more than 6% of all athletes in the study sustained brain concussion (11). The second study compared “boil and bite” versus custom-made mouthguards worn by American college football players. More than 500,000 athletic exposures were recorded; yet again, there was no significant difference between the 2 groups (27). It is important to note that these 2 studies did not assess the mechanism of injury, for example, blow under the chin versus fall to the ground. A more recent study investigated whether wearing a mouthguard reduced the neurocognitive and symptomatic impairments that follow an “injurious episode of sports related brain concussion” (26). In that study 180 college student athletes were included, all of whom had a very recent history of brain concussions that they sustained either wearing or not wearing a mouthguard. All athletes were evaluated immediately after the injury with so-called Immediate Post-Concussion and Assessment Test. The study found no difference between the 2 groups, and at the first follow-up assessment, there was no difference between mouthguard users and nonusers, which suggests that the mouthguard did nothing to reduce the severity of neurocognitive dysfunction and onset of symptoms after a sports-related head trauma (26). To further support the notion that...
mouhtguard does not protect the brain from injury, there is a recent systemic review of the literature in which the authors conclude that no strong evidence exists for the protection of mouthguards against brain concussion (28). Alarmingly, several manufacturers of stock mouthguards do make quite unsubstantiated claims regarding their product in print and the Internet. Some have even gone so far as to market stock mouthguards under brand names such as “Brain Pad” and “Brain Pad plus.” Despite studies that have shown specifically no added benefits of those elaborate and often more expensive mouthguards, some of the manufacturers did not change their tune. For example, one study found no significant difference between the effectiveness of one of these padded dual jaw mouthguards, Wipps Brain Pad (Wipps Products Inc, Conshohocken, Pa), and the “old type” guards in the prevention of concussion injuries in athletes participating in varsity football and rugby, yet the manufacturer still maintains the claim on its Web site (29).

Faceguard

First reports of using face protection in American football dates to 1955 when the helmet manufacturer Riddell (Elyria, OH) introduced a football helmet with a single face-bar (30). From the single bar the faceguards evolved to a cage of metal or composite that is attached to a helmet. About the same time in 1959, one can find the first record of a National Hockey League goalie wearing a mask-like faceguard, something that has become standard for everyone. Recently, guards made out of clear polycarbonate plastic have become available as either prefabricated or custom-made. It would appear that these faceguards provide good protection to the face and the teeth but are not applicable to all activities: in some cases they might not protect the teeth if the individual is hit under the chin (31).

Few large-scale studies have been conducted on the actual benefits of wearing faceguards in games or practice, and it is clear that the introduction of mandatory helmet and face protection has been effective in virtually eliminating ocular, facial, and dental injuries in juvenile hockey (9). However, a major concern has been realized for the same effective in the prevention of concussion injuries in athletes participating in varsity football and rugby, yet the manufacturer still maintains the claim on its Web site (29).

Specifically on Mouthguards

What Types Are Available and What Is the Difference?

Mouthguards can be divided into 3 basic types on the basis of how they are manufactured and used:

1. Stock prefabricated
2. Mouth-formed
3. Custom-made

Some of these basic types now have several subgroups, especially the custom-made ones.

Stock mouthguards may be made from either rubber or one of the plastic materials. They are generally available in 2 or 3 sizes and are supposed to have a universal fit, sometimes aided by flanges in the molar area. Modification is limited to trimming the margins to relieve the frenula and second molar area. The loose fit means that the wearer must occlude to prevent the guard from being displaced. The main advantage of this type of mouthguard is that they are inexpensive and may be purchased by the public in sports shops. Also, because they do not require any preparation, a replacement is readily available at any time. Most reports agree that these types of mouthguards provide the least protection of all available types because of their poor fit, although admittedly, there are no conclusive scientific data confirming this opinion (34). However, it is unquestioned that these mouthguards are rather uncomfortable for the wearers, they tend to obstruct speech and breathing because the wearer literally must keep them in place by clenching, and when needed, most of the mouthguard could be blown out of the mouth before impact with the ground or other obstacles.

There are 2 types of mouth-formed mouthguards that may be made from a manufactured kit. The first consists of a hard and fairly rigid outer shell that provides a smooth, durable surface and a soft, resilient lining that is adapted to the teeth. The outer shell of vinyl chloride is then to be lined with a layer of self-curing methylmethacrylate or silicone rubber. The outer shell is fitted and trimmed, if necessary, around the sulci and frenula attachments. It is filled with the soft lining and seated in the mouth. This type of mouthguard tends to be bulky, and the margins of the outer shell may be sharp unless protected by an adequate thickness of the lining material.

The most commonly used type of mouth-formed protector is constructed from a preformed thermoplastic shell of polyvinyl acetate-polyethylene copolymer or polyvinyl chloride that is softened in warm water and then molded in the mouth by the user. These mouthguards have several distinct advantages over the stock mouthguard. If carefully adapted, they give a closer fit and are more easily retained than stock protectors. Care must be taken during the molding process so that the mouthguard fits accurately. The temperature necessary to allow adequate adaptation to the teeth is fairly high, so additional care must be taken to avoid burning the gingiva.

Similar to the stock mouthguard, this type of mouthguard is relatively inexpensive and readily available to the general public and can be formed into a decent appliance with some care.

Custom mouthguards are individually made in a laboratory on plaster of Paris models poured from impressions of the player’s mouth. Many studies have shown that these mouthguards are more acceptable and comfortable to athletes than the other types (35).

There are very few studies that show conclusively that one mouthguard type is better than another in protecting the athlete’s teeth or oral tissues. There are studies that show that custom-made ones do not afford any better protection against brain concussion when compared with the stock types (27–29). The data on differences between types of mouthguards on oral and dental protection are not as clear (13, 36).
Further studies are needed in which prospectively large cohorts are to be monitored and evaluated over a long time.

**Multilayered Custom Mouthguard**

In 1985 Chaconas et al (37) described a laminated thermoplastic mouthguard that showed significantly less dimensional change than other materials tested (ie, polyvinyl acetate-ethylene, copolymer clear thermoplastic, polyurethane). Thus was the start of several different subcategories within custom-fabricated mouthguards. Subsequent to this, layered ethylene vinyl acetate stock plates were introduced. The idea was to further strengthen the mouthguard and increase its protective capacity. When a stock plate of ethylene vinyl acetate is fabricated, it is drawn out in one direction so that the polymer chains are more or less parallel, like the grain in wood. This can theoretically make a difference in properties whether the “grains” are running faciopalatally or mesio-distally on the crown of the tooth, the layered stock has 2 or more layers arranged in perpendicular similar to plywood sheaths. There is not much, if any, scientific proof that this can increase the protective ness of the mouthguard *in vitro*, although few *in vitro* studies indicate a difference (38–41). There is a question of whether a too stiff mouthguard could not cause other damage to the tooth or alveolus if rather than it absorbing the energy, it just transfers the energy to the roots of the teeth or alveolar bone. Some alarming findings to that effect have been reported in an *in vitro* study some years ago (42). In that study it was found that a hard insert resulted in reduced energy absorption when compared with a control sheet of the same material and approximate thickness but without the hard inserts.

The main question regarding these various types of mouthguards is whether there is any actual protective difference between them. No studies have investigated the efficacy *in vivo* of the different types in preventing dental injuries with large enough samples to have a significant power.

**Educational Prevention**

It has been estimated that between 20% and 30% of all 18-year-olds have sustained injury to their teeth, and one-third of those are serious enough to potentially cause permanent damage (43). There is a good indication that oral and dental injuries occur as much if not more often during children’s play or leisure activities than in organized games or sports (44, 45). For example, in a study by Skare and Jacobsen (46) in Norway in 2003 nearly half of the 1275 injured indi-

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**Future Research in Prevention of Dental Injuries**

Unfortunately, there is a large hole in our evidence-based knowledge on prevention of dental trauma. Many do believe that a mouthguard will protect the teeth and even the brain, but without good randomized clinical trial study, the evidence supporting that belief is weak at best. Case studies on a few athletes in which they are asked once after the season if they used mouthguards and if they sustained an oral or dental injury are not valid evidence. For ethical reasons it is difficult to do a true prospective randomized study on the effectiveness of some of the suggested protection devices. There are still many organized sports that do not require mouthguard and/or any other protection device, yet the incidence of oral and dental trauma is relatively high in those sports.
Save your tooth

Most of your permanent teeth may be saved if you know what to do after a blow to the mouth.

What to do if your tooth is BROKEN

1. Find the piece of tooth
2. The piece can be glued on
3. For this to be possible, seek attention immediately from a dentist

What to do if your tooth is KNOCKED OUT

1. Find the tooth
2. Hold it by the crown
3. (Plug the sink) Rinse in cold tap water

FOLLOW ONE OF THESE ALTERNATIVES:

a. Put the tooth back in its place
b. Place the tooth in a cup of milk or saline
c. When milk is not available, place the tooth in the mouth between the cheeks and gums

5. Seek immediately specialized dental treatment, within a two hour time period

Figure 1. Poster cosponsored by several national dental organizations and the International Association of Dental Traumatology. This poster is in the public domain and can be downloaded in several languages at http://www.iadt-dentaltrauma.org/for-patients.html.
Focus should be placed on those, and hopefully good studies will enlighten us about the true effects of those devices.

In the meantime, emphasis should be placed on education by using the most contemporary ways possible, such as the Internet and apps, on how to prevent as well as how to respond to a dental injury. Pedagogical studies on how best to approach this are also sorely lacking and would be most interesting.

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