



Sports Dentistry and Mouthguards

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SCD and GD designed the study, wrote the protocol and first draft of the manuscript. Authors UK and DK managed the literature searches and analyzing it pertaining to the title. All authors read and approved the final manuscript.

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ABSTRACT

Dental and orofacial injuries have been reported to be the most commonly occurring form of traumatic injury resulting from sport-related activities. Sports dentistry is the upcoming field in dentistry which is associated with the correct diagnosis, prevention and treatment of orofacial injuries and related oral diseases. This branch also deals with the collection and dissemination of information on dental athletic injuries and the encouragement of research in the prevention of such traumatic injuries. This article discusses an overview of sport-related injuries in orofacial and dental region, incidence, evaluation, treatment and their prevention. It also discusses the several functions and types of mouthguards. It stresses the prime role of dentist in educating the general public, parents/guardians, staffs of emergency department, coaches and athletes regarding health

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risks and benefits of mouth guards including the importance of emergency care for orofacial injuries.

Keywords: Orofacial injuries; dental trauma; mouthguards; contact sports.

1. INTRODUCTION

Sports Dentistry is referred as the branch of sports medicine that deals with the prevention and treatment of dental injuries and related oral diseases associated with sport and exercise. This branch of dentistry had its beginning in the 1980s and is related to the prevention and therapy of orofacial injuries occurring in athletes, as well as the collection and dissemination of information on traumatic dental injuries and the encouragement of research in its prevention [1].

During sports-related activities, various traumatic dental injuries are encountered, including luxation, intrusion, extrusion and avulsion of tooth, fracture of the facial bones, injuries to the temporomandibular joint (TMJ), and the most fatal concussion. These orofacial injuries further lead to consequences of trauma for participating children and their family members because of associated orofacial pain, psychological effects and socio-economic implications. Preventive measures (helmets, mouthguards, and protective gears) provided during sports have changed the incidence of such injuries to the participating athletes. Sports dentistry have responded to these athlete's specialized needs and trying to provide them with the quality care which they deserve. This review article discusses the various aspects of sports-related dental and orofacial injuries, the risk factors associated, protection, and prevention of trauma. It also discusses the role of mouthguards in prevention of traumatic dental injuries.

2. DENTISTRY AND SPORTS-RELATED INJURIES

A physically active lifestyle is essential in routine life and it is important for all age groups of people [2]. The people participate in sports and sports-related activities for the following possible reasons: pleasure, relaxation, competition, socialization, maintenance, and improvement of fitness and health. However, this participation always carries a risk of traumatic injuries, which is sometimes so fatal that may lead to permanent disability [3,4]. A drastic increases in the number of participating sports-persons involving in regular vigorous physical activity and contact

sports have been found [5]. The health and career benefits related with such activities are always associated with the serious risk of injury. Sport-persons involved in contact sports revealed 10% more prevalence of traumatic injuries as compared to those who are not involved in such contact sports [6]. National Youth Sports Safety Foundation (NYSSF) has reported the prevalence of 33-56% risk of causing a facial injury in athletes participating contact sports [7]. Andresean and Andresean [8] stressed the major role of a dentist in providing comprehensive care in such sport-related injuries. A dentist must be knowledgeable and adept in the areas of oral surgery, endodontics, operative dentistry, orthodontics, hospital dentistry, and patient behavior management [8]. Dentists must deal with patients with various types of fractures of tooth and facial bones. Traumatic dental injury in sports is the main link between the sports and dentistry. Castaldi [9] and Castaldi [10] governed the factors such as the popularity of organized youth sports and the high level of competitiveness, to be cause of recent rise of prevalence of orofacial injuries. Approximately, 46 million young athletes in the United States participated in some form of sports in the last decade [11]. About 30 million youth in the US participate in organized sport programs [12]. Almost all types of sports have an increased risk of traumatic injuries and these are resulted from falls, collisions, contact with hard surfaces or equipments [3]. They reported that sports-related accidents account for approximately 10 to 39% of all dental injuries occurring in children. Gassner and colleagues [13] reviewed cranio-maxillofacial trauma cases presenting to the department of oral and maxillofacial surgery in 10 years. Approximately, 3,385 cases with 6,060 injuries were reviewed by them among which, 31.8% of injuries in children were related to sports-related activities. Children between the age group of 7 and 11 years are most susceptible to sports-related traumatic dental injuries [14-17]. The administrative personnel of young athletes, high school and college, football, lacrosse and ice hockey recognized the need of protective device in reducing such injuries. Athletes involved in baseball and basketball demonstrated a higher prevalence of dental injuries, especially between the age groups of 7-

17 years [17]. Furthermore, on the basis of a large national survey, bicycle was found to be the most common consumer sports product related to dental injuries in children [17]. Several other authors [17-20] informed that youths participating in leisure activities (skateboarding, inline or roller skating, and bicycling) also benefit from appropriate protective equipment. American Academy of Pediatrics (AAP) [21] governed specific policies in relation to trampoline safety in young athletes. AAP recommended the use of the trampoline to provide specialize training for some types of sports. This academy also recommends the dentists advice athletes and their family members against recreational trampoline use. It also, governs that current safety measures have not decreased the prevalence of injuries significantly [21].

Several studies [22-25] documented the variations in the injury rate and observed its association with the size of the sample, the sample's geographic location, the ages of the participants, and the specific sports involved in the study. Glendor [24] correlated the etiology and risk factors related to traumatic dental injuries and showed that the rate of injury depends on the athlete's level of competition. He found a higher prevalence of sports-related injuries in less-professional and amateur athletes than professional athletes. The dento-facial trauma is often associated with serious consequences like esthetic, functional, economic and psychological and depends on severity. These traumas are more commonly occurring in sports such as mountain biking, roller, skate and aggressive contact sports.

Huang and colleagues [25] documented the highest occurrence of traumatic dental injuries in young male athletes in the age group of 15-18 years. Sports-related dento-facial injuries have been reported more oftenly and participation in sports have been consistently associated with the risk of such injuries [22,23,26,27]. Some studies [28,29] highlighted the effects of dento-alveolar traumatic injuries on the quality of life of children. Post-traumatic consequences for the affected athletes and their family members are heavy-hearted due to the episodes of pain, psychological effects and financial burden. Athletes with untreated traumatic injuries to permanent dentition reveal greater psychological impacts on their routine living than those without such trauma. The yearly expenditure on such traumatic injuries was estimated to be more than 1.8 billion dollars [12].

Traumatic dento-facial injuries contribute a significant impact on the social and economical aspects of the affected athlete along with his family [30-33]. The expenses for restorative, endodontic, prosthodontic, implant or surgical therapies develops a considerable financial burden on such families. Several investigations [22,23,34] documented that the majority of sports-related injuries involve the upper lip, maxilla, and maxillary incisors, with 50 to 90% of dental injuries affecting the maxillary incisors. Muller and colleagues [35] surveyed the incidence of dental injuries in four countries including Switzerland, Austria, Germany and Italy and observed that the anterior teeth are the most commonly affected by dental trauma. The upper incisors are most predisposed to injury (52-90%), due to their anatomical location. The prevalence of uncomplicated crown fractures was 44-62.5%. The prevalence of enamel fractures in Pan American Game's athletes was 39.8% and 21.9% of these were observed in daily practice of sports [36]. Approximately, 41.2% of the athletes in jiu-jitsu suffered dental trauma, 37.1% in team handball, and 36.4% in basketball, football 23.2%, 22.3% in judo and 11.5% in hockey [37]. Coto and colleagues [38] found the nasal bone to be the most affected structures in sports accidents, as it is located in a vulnerable area of the face and projected forward in relation to adjacent structures. Gassner and colleagues [39] compared the prevalence of oral and maxillofacial trauma in athletes participating mountain biking and bicycling and found that the zygomatic bone was involved about 30.8% and TMJ with a rate of 18.8%. This suggested adopting certain preventive measures against high impact sports to minimize effects of trauma that can end the career of an athlete.

Dental practitioners can identify athletes participating in sports-related activities and can suggest definite preventive protocols for those who are at considerable risk for traumatic dental injuries. Such prediction led to the development of a predictive index in 2000, which assessed identifying risk factors involved in many sports [27]. This index is dependent on demographic data, preventive or protective equipment, velocity and intensity of the sport, level of activity and exposure time, level of coaching and types of sports organization, and the situation. Laloo [40] and Sabuncuoglu [41] discussed the behavioral risk factors (eg, attention-deficit hyperactivity disorder) and its significant linkage with traumatic dental injuries. Several authors [42,43] observed a significant relation between the frequency of

dental trauma occurring in children and increased overjet and inadequate lip coverage. Bauss and colleagues [42] suggested initiating preventive orthodontic treatment in early-to-middle-mixed dentitions of young athletes to prevent traumatic injuries to the permanent incisors. Majority of sports-related traumatic injuries are unavoidable, but it can be better prevented [27,44].

3. FACIAL BONES INVOLVED IN SPORTS-RELATED INJURIES

The diagnosis and management of sports-related traumatic injuries involving the face should be evaluated for abrasions, contusions, and lacerations to rule out fracture or any other underlying injury [45]. Guyette [46] surveyed the facial injuries occurring in basketball players and found that these injuries occur over a bony prominence of the facial skeleton (brow, cheek, and chin). Padilla and Balikov [4] reported that the fractures of the facial bones present more complex types of problems. They observed the zygoma (cheekbone) to be the most common and frequent site of bony injury affecting the face. Approximately 10% of the maxillofacial fractures were found to be related to the zygomatic bone. These findings were most consistent due to direct blunt trauma from a fall, elbow, or fist occurring in sports. Linn and colleagues [47] observed that amongst 319 patients treated for sports-related traumatic injuries, male athletes proved to be more prone to zygomatic fractures compared to females. The authors correlated the higher prevalence of zygomatic fractures in males to the powerful physical contacts during sport activities. Camp [48] documented the prominent shape and projection of the mandible as the causative factor contributing traumatic injuries to this bone, similar to the zygoma. The author reported that approximately 10% of maxillofacial fractures from sports-related activities occur in the mandible when the athlete strikes a hard surface, another player, or equipment. When mandibular fracture occurs, the airway management of the patient becomes the prime concern as a part of immediate care. Guyette⁴⁶ observed that the condyle is the most vulnerable part of the mandible, in both children and adults. Fractures of the mandibular condyle have the ability for long-term deformity of the face. The author documented a significant data from survey mentioning that condylar fractures in children can alter growth of the lower face.

Blows occurring to the mandible can transmit a significant amount of force to the TMJ disc and its supporting structures, which may lead to permanent injury. In such injuries, the condyle can be forced posteriorly in such an extent that the retrodiscal tissues are much compressed. This further causes inflammation and edema resulting in forward and downward positioning of the condyle, which may develop acute disturbances in occlusion. Sometimes, this type of traumatic impact may cause intracapsular bleeding, if persists further result in to ankylosis of the TMJ.

4. TOOTH OR CROWN FRACTURES IN SPORTS-RELATED INJURIES

The traumatic dental injuries involving crown fractures of the permanent dentition may present in several different forms, the simplest form being the crown infraction [48]. This infraction exhibits a crazing of enamel structure without any loss of tooth structure and not requiring any therapy except pulp vitality testing. Padilla and Balikov [4] showed that the crown fractures involving the dentin are often very sensitive to temperature and other types of stimuli. In severe form of crown fracture, the pulp is fully exposed and contaminated in a closed apex tooth or a horizontal impact of injury resulting in the fracture of the root. Mobility determines to be the main clinical sign of root fracture. Radiographic investigations adjoined with the examination of the adjacent teeth, are essential steps in determining the location and severity of the fracture and possibly involvement of alveolar bone. The therapy is implemented on the basis of the level of the injury.

Complete avulsion of a tooth is one of the most dramatic sports-related dental injuries. The avulsed tooth may be replaced with varying degrees of success depending solely on the length of time period the avulsed tooth is outside its socket. An avulsed tooth shows a good chance of recovering full function if the periodontal fibers attached to the root are not destroyed due to handling. Andreasen and Andreasen [49] have reported a success rate of 90% if the avulsed tooth is replaced in the socket within 20 minutes of the trauma. They found a decrease in success rate by 10% for each additional 5 minutes that the avulsed tooth is out of its socket. Guyette [46] observed that the periodontal fibers attached to the root of the replaced tooth undergo necrosis and the tooth undergoes resorption and finally lost.

5. PREVENTIVE MEASURES OF SPORTS-RELATED DENTOFACIAL INJURIES

Keeping in view the high prevalence and incidence of sports-related dentofacial injuries, the primary health care personnel, such as school nurses, trainers, physicians, and emergency personnel) should be offered specialty training in assessing and managing traumatic dental injuries in young athletes. The dental team members can train these providers such that they will identify and understand the preventive protocol for traumatic dental injuries while providing immediate therapy in such accidents. The American Dental Association (ADA) has requested its responsible members to work together with primary health care personnel developing mouthguard programs and certain guidelines to prevent sports-related injuries.

Nowjack-Raymer and Gift [50] advocated the use of mouthguards and headgear in organized sports by school-aged children. Mouthguards and headgear can be used to prevent sports-related dentofacial injuries. But, National Institute of Dental Research (NIDR) observed an inconsistent wearing of mouthguards and headgear during organized sports. In sports like football, approximately 75% of participating athletes were noted following the wear of mouthguards. Glik and colleagues [51] reported that the parental perceptions of children's risks to traumatic injury, expenses associated with protective gear, and peer pressure may influence use of mouthguards. They observed a higher awareness in lower socio-economic parents regarding threats to their children's safety compared to high socio-economic parents. The observed pattern of mouthguard wearing by male and female athletes can represent their cultural and social differences, peer pressure, and/or nature of sports played. Females exhibit less aggressiveness and hence, are placed at a lower risk of dentofacial injuries. Also, their esthetic appeal may restrict the wearing of protective orofacial gear [50].

Ranali and Lancaster [52] suggested the influencing role of coaches in using mouthguards by sport athletes. Unfortunately, mouthguard compliance by athletes is usually not insisted upon by their coaches or referees [53]. DeYoung and colleagues [54] reported the poor perception of coaches or referees towards the knowledge of mouthguards. The coaches receive most of the

information of such protective equipments either from sales representatives (72%) and educational materials (33%), or dentists (11%). Winters [55] stressed the role of sports dentistry in athletics.

6. SPORTS-RELATED DENTOFACIAL INJURIES AND MOUTHGUARDS

Mouthguard is a device worn over the teeth that protects them from blows to the face and head. Sports guards or mouth protectors are synonyms for mouthguards. These are an important piece of athletic equipment for anyone participating in a sport that involves falls, body contact or flying equipment. This includes football, basketball, baseball, soccer, hockey, skateboarding, and gymnastics, mountain biking and any sports-related activity that might result in an injury to the mouth.

A well fabricated, custom-fitted mouthguards with an adequate fit lower the incidence of concussion and any injuries to the dentofacial region [56,57]. Mouthguards relieve the stress concentrated on the frontal teeth by absorbing and dispersing shock energy and readily stopping the vibration of the upper anteriors [58]. Approximately, 51.6% of national hockey league athletes wear a mouthguard during their sport activities [59]. A professional athlete cannot be forced to wear a mouthguard, instead the owners or league administrative personnel must educate their athletes making mouthguard wearing compulsory.

One of the major fears expressed by the athletes towards the use of mouthguards was their belief on these safety protectors causing hindrance in their breathing. However, recent study observed no effect on aerobic performance in female athletes, while wearing custom or prefabricated mouthguards [60].

7. FUNCTIONS OF MOUTHGUARDS

Mouthguard serves the following basic functions while preventing athlete from sports-related traumatic injuries: [61]

1. It acts as a buffer between the soft and hard dento-oral structures, thus preventing any laceration and bruising during trauma.
2. It provides cushioning effect between teeth from direct frontal impact and redistributes the forces of blow.

3. It protects the opposing dentition from seismic contact against each other.
4. It prevents the fracture or damage to the unsupported angle of the mandible during impact.
5. It helps to reduce neurologic injury by behaving as shock absorbers between both the jaws. Otherwise, the trauma may be transferred from the condyles against the skull base resulting in concussion.
6. It provides a positive reinforcement against neck injuries [62].
7. It provides a psychologic benefit to athletes as it offers confidence in terms of protection [63].
8. It fills empty spaces, thereby providing support to adjacent teeth. This benefit permits the athlete to take out his/her removable prosthesis during competition.

A routine and professional examination is necessary for the fit and function of mouthguard. This depends on various factors such as the age of the athlete, the requirement of the sport that the athlete is participated in, and the readiness of the athlete to properly care for the appliance. The number of appointments for examining such appliance is decided by the dental professional, which further depends on each individual situation and athlete. Mouthguards typically are fabricated from thermoplastic copolymer and designed to fit over occlusal and facial surfaces of the maxillary teeth and gingival tissues [64].

8. STOCK MOUTHGUARDS (SMGs)

ADA [65] has recommended that the stock mouthguards may be bought from the sources like a sporting goods store, pharmacy, or a departmental store. SMGs are composed of rubber, polyvinyl chloride or a polyvinyl acetate copolymer. Kerr [66] has mentioned the major advantages and disadvantages of mouthguards for the prevention of injuries in contact sports. The advantage of SMGs is that it is relatively inexpensive. But the disadvantages include their availability only in limited sizes, improper fit, inhibition in speech and breathing, and need of closing the jaws to hold the mouthguard in place. SMGs are the least preferred type, least expensive and effective. These are available in a limited number of sizes, which forces the athlete to modify it for better fit and function. SMGs provide a low level of protection comparatively [67]. If the wearer becomes unconscious, the appliance may be lifted from its position causing an airway obstruction [68]. Due to improper

fitting, mouthguards may develop discomfort and irritation while wearing by an athlete. However, orthodontic specialists recommend SMGs as this appliance protect the soft tissues while allowing tooth movement. However, ASD do not recommend SMGs as an orofacial protective appliance due to their inadequate protection of teeth [69].

9. MOUTH-FORMED PROTECTORS (MFPs)

MFPs are available in two varieties: the shell-liner and the thermoplastic mouthguard. The shell-liner is composed of a preformed shell with a liner of plastic acrylic or silicone rubber. The liner is kept in athlete's mouth and molded around the teeth and finally allowed to set. The second type i.e. the preformed thermoplastic has a lining that is immersed in boiling water for 10-45 seconds, after which it is transferred to cold water and then adapted to the teeth. This type of MFPs is also known as 'boil and bite' guard. This type of mouthguard is the most popular of the available three types and is used by more than 90% of athletes [70]. These mouthguards are most commonly used, but they do not provide the proper thickness, comfort, or critical protection of the posterior teeth. Often, because of the inaccurate fit, clenching pressure is required to obtain satisfactory retention.

10. CUSTOM-MADE MOUTHGUARDS (CMMs)

CMMs are the superior of the three types of the mouthguards and the most expensive to the athlete. ADA [65] has recommended this type of mouthguard for athletes to prevent sports-related injuries. CMM is made of thermoplastic polymer and fabricated over a stone model of the athlete's dentition. This mouthguard is considered to be well worth the cost to protect athlete's teeth from traumatic injuries. It is fabricated by the dental professional and fits accurately to the athlete's mouth. Among the several advantages of CMMs includes: [71] accurate fit, ease of speech, comfort and retention. The best benefit of such type of mouthguard is that it significantly reduces the incidence of a concussion due to forward placement of mandible [72]. CMMs can be divided into two types: custom vacuum formed mouthguard (CVFMs) and pressure-laminated mouthguards (PLMs). CVFM is the most common and widely fabricated mouthguard by the dental professional. It provides adequate

protection from the sports-related traumatic dental injuries. It also offers least amount of interference to speaking and breathing. These are prepared from a single sheet of EVA polyvinyl acetate-polyethylene copolymer. The sheet is heated, placed over the stone model, and suctioned by vacuum to fit to the shape of the mouth and teeth. Such procedures decrease its thickness occlusally by 25% and buccolingually by more than 50% [73]. These mouthguards retain their shape for only a few weeks after wearing and does not provide protection for long periods of time. PLMs are fabricated from multiple sheets of laminating EVA materials that are heated, placed over a stone model, and pressed onto the model with a maximum pressure of 6 atmospheres. These layers are then fused together forming a thick and protective mouthguard. It is more retentive compared to other types of mouthguards and allow for a more balanced occlusion. It exhibits negligible deformation when worn for prolonged period of time. These are typically fabricated by dental professional or dental laboratories. Several advantages of PLMs includes: allow for effective communication, no interference with breathing, less wear in chewing and biting, more comfortable to wear, and allows uniform thickness of guard material. Padilla [74] reported that PLMs offer the best protection for children's teeth during all types of sporting activities.

11. ROLE OF DENTAL TEAM IN PREVENTION OF SPORTS-RELATED INJURIES

Dentists must educate the general population regarding the need and benefits of mouthguards during sport activities. The organization such as the American Dental Association (ADA) publishes brochures explaining different types of protective mouthguards including their benefits. The non-profit educational research organization like National Youth Sports Safety Foundation (NYSSF), promotes the safety measures for young athletes. It publishes a fact sheet on dental injuries that includes statistics, costs of injuries, resource information regarding standards for mouthguards, videos, and mouthpieces and dental care [75].

A dentist can carry a field emergency kit before attending a sporting event. An increasing participation of youth in sport competition develops a basic need for protective mouthguards. Dentists need to conduct researches or surveys to determine the

prevalence and incidence of sports-related injuries in their communities. Such research combined with preventive measures can help out in determining the proper legislation. Mouthguard laws would help to reduce the number of sports-related dento-facial injuries and protect participating athletes. The sports dentistry branch is a real challenging, yet rewarding one. Untiring efforts from dental professional and other health care providers can provide a better awareness of the types of traumatic injuries, therapeutic procedures, and protective appliances to athletes and their families.

Elliott [76] discussed the professional responsibility of the dentist in sports dentistry. Sports dentistry should encompass beyond the protective appliance fabrication and the treatment of fracture dentition. Being a dental professional, it is his moral responsibility to become and remain educated and pass that education on to the community regarding sports dentistry and especially to the prevention of sports-related oral and dental trauma. One of such organizations such as Academy for Sports Dentistry (ASD), contribute to overall efforts eliminating dento-facial injuries in sports-related activities. The ASD conducts various educational programs and publishes a biannual newsletter. It also offers an annual symposium for dental professionals and other health care providers interested in trauma and its prevention. It promotes legislative efforts and encourages research work in all oral and dental related issues.

12. SUMMARY

Dental and orofacial traumatic injuries are not uncommon during the participation in organized and unorganized sports and sports-related recreational activities. Sports dentistry governs all the preventive and therapeutic measures of orofacial athletic injuries and related oral diseases and their manifestations. With the increasing sports participation of children and adolescents in schools and colleges, protective and preventive measures becomes utmost important for a dental practitioner. Dentist as a health professional must have a sound clinical experience and knowledge about sports-related dento-facial injuries and must work in association with the teachers, coaches, trainers, parents, sports administrators and other health care providers to provide deserved immediate dento-facial care. Dentist has a great responsibility to pass his education on to the community

regarding sports dentistry and specifically to the prevention of sports-related dental and orofacial trauma. Mouthguards protect against orofacial injuries and reduce the incidence and severity of sports-related injuries that occur during athletic practice and competition. Many athletes are not aware of the consequences of a traumatic injury to the dento-facial structures while playing. The incidence and prevalence of orofacial injuries undergoes a paradigm shift with changes in sports equipment and regulations. Dentist must emphasize on improving the quality of mouthguards for sportsperson's safety as one way of attempting to reduce such injuries that may end their career. Sports dentistry should mandate the use of protective devices especially mouthguards in all sports starting at the local and state levels.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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