

Role and Fabrication Method of Custom-made Mouthguards for the Prevention of Athletic Injuries

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Summary

Orofacial injuries are athletic injuries which are specific according to place and way of occurrence. Sports dentistry is a dental discipline associated with the prevention and treatment of the consequences of orofacial injuries during sport activities. Orofacial, and particularly dental athletic injuries, differentiate according to way of occurrence from other dental injuries and can be easily prevented. By using an adequate mouthguard a number of dental and periodontal injuries can be considerably reduced. There are different intraoral mouthguards: stock, mouth-formed and custom-made mouthguards. Even though with the stock and mouth-formed mouthguards a visit to the dentist is avoided, only custom-made mouthguards offer maximum prevention from orofacial injuries. By its construction and technological features it is the most comfortable for athletes during training and competition. Preconditions for wearing mouthguards are good oral prophylaxis and restoration of all teeth (without caries and periodontopathy). The mouthguard is commonly fabricated on the upper dental arch. Mouthguards are manufactured from materials that should satisfy numerous physical, mechanical, biological and functional requirements. Fabrication method of a mouthguard by means of vacuum lamination is presented. The role of the mouthguard is to prevent laceration of the tongue, lips and cheeks by the sharp edges of anterior maxillary teeth, to reduce the risk of injuries to the anterior teeth, to reduce the risk of mandibular or maxillary fractures as well as damage to the posterior teeth and temporomandibular joints, after blows to the interior aspect of the mandible. Athletes should be informed of the possibilities of prevention of their oral health as well as of the existence of slight difficulties which are inevitable during wear of a mouthguard.

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Orofacial athletic injuries

Injuries to the teeth and soft tissues of orofacial structures are today a very common health problem. Loss of teeth are very often the consequence of misuse of preventive procedures. According to aetiology a separate group of dental trauma are athletic injuries which are characteristic for many sports (1,2). Therefore in the eighties of the last century the dental discipline associated with the prevention and treatment of orofacial injuries in sport was established. The importance of sports dentistry has become even greater due to the role which sport has in modern society (3,4).

During team and individual sports close physical contacts and the use of uncontrolled forces and directions on the competitors are very common. Such groups of sports are defined as contact sports (football, icehockey, boxing) (5-7). Moreover, there is a possibility of injuries by certain sports equipment. Injuries can occur because of a fall on the ground or on the sports equipment. Consequences can be very serious orofacial injuries with permanent loss of teeth. In addition to the fracture and extrusion of tooth there is a possibility of the fracture of orofacial bones (jaws, temporomandibular joint, zygomatic arch and lower orbital edge). Aside from sports competitions, professional and amateur athletes are liable to injuries during training which are integral parts of every sports activity. Recreational sport deserves even more attention because the injuries are more often due to the lack of physical conditions of recreationists. One group of extreme sports is particularly dangerous (mountain-biking, skateboarding, rollerskating) (8,9).

Regarding the frequency and severity of orofacial injuries in different sports the risk in certain sports activities was evaluated. World Dental Federation (FDI, 1990) classified sports into high risk sports (boxing, soccer, American football, hockey, martial arts, rugby, ice-skating and hang-gliding) and moderate risk sports (basketball, platform diving, gymnastics, parachuting, horse riding, squash, water-polo, handball, cricket and baseball). By emphasizing the risk of certain sports the recommendations and

guidelines for intensive prevention of orofacial and other athletic injuries have been improved (10-12).

Epidemiology and prevention of athletic injuries

The most common injuries to the teeth and oral cavity (13 to 39%) are associated with sport. Beside minor injuries, such as lacerations of soft tissues, the loss of one or more teeth as a result of such injuries can occur. The most frequent injuries are those of the upper incisors, which amount to 80% of cases. Less frequent are fractures of the mandible and temporomandibular joint and haematoma (7.6% of cases) (12-15).

Numerous investigations on the causes, frequency and type of injuries of orofacial structures have been conducted, as well as on the use of preventive measures and their effect on reduction of injuries. The most common injuries in water-polo are in the orofacial region (96.4% of cases), of which 80% are injuries to the lips, tongue and cheek. Dental trauma occurs in 7.6% of cases, whereas other injuries other than the oral region are eye injuries in 14.3% of cases (16). In a survey of basketball players injury to the soft tissues of the orofacial complex was determined in 69.4% of respondents and dental trauma in 11.3%. Only half of the examined professional basketball players wear mouthguards (17). In the selected sample of Croatian top-handball players injuries to the soft tissues were determined in 78.8% of cases, dental trauma and loss of teeth in 13.6% and temporomandibular joint injuries in 6.8%, and only one of the players from the sample wears a mouthguard, which is not satisfactory (18).

Primary prevention includes prevention of injury occurrence. As preventive means helmets, vests, masks, facialguards and mouthguards are used. For the protection and prevention of orofacial and dental injuries different types and forms of intraoral mouthguards are used. By using a mouthguard great reduction of the frequency and severity of dental injuries is achieved, while lips, tongue and mandibular injuries are also significantly reduced. By its use intracranial force is amortized by 50%, which can

cause cerebral concussion, fracture of the temporomandibular joint and neck injuries. In a numerous population of American athletes of all ages, just in the segment of American football, by using mouthguards the frequency of orofacial injuries was reduced to only 1% (3,4,8,13).

Mouthguard

The most rapid development of mouthguard technology occurred in the United States of America between 1950 and 1965 when extensive studies of the shape and placement and material testing were undertaken. With development of sports dentistry and research of the prevalence and aetiology of athletic injuries, mouthguards were revealed as an indispensable instrument for the successful prevention of injuries to the orofacial tissues and organs (19).

According to placement a mouthguard can be extraoral, intraoral or combined. An extraoral mouthguard is fixed to the helmet in the form of a protective net or grate. An intraoral mouthguard is placed on the dental arch. There are monomaxillary and bimaxillary mouthguards. A monomaxillary mouthguard has retention on one dental arch. A bimaxillary mouthguard with its construction, has retention on both dental arches and must be able to facilitate normal breathing. It stabilizes the mandible in order to reduce the danger of its fracture as well as injuries to the soft and hard tissues of temporomandibular joints. In edentulous patients the modified bimaxillary mouthguard is manufactured. A combined mouthguard incorporates constructional elements of the extraoral and intraoral mouthguard (20,21).

- Intraoral mouthguard should possess the following characteristics (12,22):
- Covers the dental arch and gingiva of the maxilla and mandible.
- Offers wearing comfort and protects from traumatic force.
- Does not interfere with habitual occlusion and mandible position.
- Adaptable to soft and hard tissues without

interference and limitation of tongue movements.

- Protects teeth, gingiva, lips and tongue.
- Enables fabrication with optimal clinical and laboratory costs and subsequent care.
- Does not cause psychological problems during wear and physical work.
- Adaptable to fixed orthodontic appliances and mixed dentition.
- Retains form after removal from the mouth and after longer nonuse.
- Modifies easily to offer protection to the lips and nasal area.
- Does not interfere with speech or breathing.
- Does not have an offensive odour or taste.
- Does not cause toxic or allergic reactions.

Material for fabrication of mouthguards should possess various physical, mechanical, biological and functional properties. The most common materials for mouthguard fabrication are: polyvinyl acetate-polyethylen or ethylen-vinyl acetate (EVA) copolymer, polyvinylchloride, natural rubber, soft acrylic resin and polyurethane (12,22,23).

There are three different types of intraoral mouthguards which are different according to individual adaptability grade to the athlete and this depends on: method and complexity of fabrication, protection grade and wearing comfort (3,12,22):

Stock or ready-made mouthguards are available without a visit to the dentist, have poor retention and are not comfortable for wearing. The athlete holds them in place by clenching the teeth together, and because of inadequate individual adaptability they fall out easily and induce vomiting. They are made from rubber or polyvinylchloride.

Mouth-formed mouthguards have better individual adaptability. The dentist form this type of mouthguard, most often by previous boiling and direct application in the mouth on the dental arches or on plaster casts. They are made from polyvinylchloride. With adaptation of the mouth-formed mouthguard better retention is achieved,

which decreases during wear. Athletes very often avoid the correct method of fabrication and manufacture it themselves. Therefore, the disadvantages of this type of mouthguard are result the of unprofessional fabrication.

Custom fabricated mouthguard is the best type of mouthguard which is completely adopted to the features of each individual. The mouthguard is fabricated over a dental cast according to individual proportions and therefore optimal retention and adaptation on the teeth, gingiva and palate is achieved. There are different fabrication procedures. The most commonly used materials are EVA copolymers, soft acrylic resin and polyvinylchloride. Fabrication procedure is the most complex and several visits to the dentist are inevitable. The custom fabricated mouthguards are considered to preferable with regard to comfort and the degree of protection provided.

Intraoral mouthguard

The preconditions for use of the intraoral mouthguard are good oral prophylaxis and restoration of all teeth (without caries and periodontopathy). It is usually fabricated on the upper dental arch (Angle class I and II), while in pronounced prognathism it is placed on the lower dental arch (Angle class III) (12). For the prevention of injuries more attention should be paid to athletes who wear partial dentures, those who wear fixed orthodontic appliances and athletes with malocclusion Angle class II (24).

Clinical and laboratory fabrication procedures of custom- made mouthguards constitute the following phases: preliminary impression of the mandible and maxilla in alginate, transfer of the upper dental arch into the articulator and centric register, laboratory fabrication, finishing and polishing and finally insertion in the patient's mouth, adjustment and subsequent care.

The shape and surface of the mouthguard which encloses teeth, gingiva and hard palate can vary depending on the anatomic features of the athlete's jaw and dental arch, on the sport discipline and material used. In its basic shape the mouthguard encloses the upper dental arch

to the second molars. It should not extend distally further because of more pronounced breathing problems. The labial flange extends to within 5 mm of the deepest part of the labial sulcus and within 1 mm of the highest parts of the labial sulcus. On the hard palate the mouthguard extends to around 10 mm above the gingival margin and encloses the major part of the anterior surface of the palate with slight narrowing toward the molars (Figure 1).

Laboratory fabrication of the custom- made mouthguard is based on casts which are installed in the articulator. A custom- made mouthguard is commonly fabricated on the upper dental arch by means of the following fabrication techniques (3,8,22,25-27):

- Fabrication by vacuum- forming technique (for example Erkoform®, Erkodent; Figure 2).
- Pressure- lamination technique.
- Combined vacuum- pressure technique.
- Photo-polymerization.
- Polymerization under pressure and temperature.

The custom- made mouthguards differ in thickness and structure. Standard thickness is around 4 mm. Some mouthguards are of stronger construction (thickness around 5 mm) while some are thinner (thickness around 3 mm). Very often they are coloured which make them more attractive for wearing. Materials suitable for intraoral mouthguards must possess optimal consistency which amortize blows. According to the structure mouthguards can be single and multiple- layered (usually double- layered). By pressure- lamination technique, for example in the vacuum device, the mouthguard is fabricated in layers of different materials (for example, a soft layer of EVA copolymer and a hard layer of styrolbutadine copolymerisate, Erkoloc®, Erkodent) or identical material of different thickness. The manufacturer's technology and adequate fabrication should enable good mutual bonding of layers (24,25).

Important properties of mouthguards are: water absorption, density and thickness of the

finished mouthguard, temperature transfer, energy absorption, drawing strength. The most commonly used material is EVA copolymer. Energy absorption, as one of very important properties, depends on thickness of the mouthguard. During fabrication and finishing of the mouthguard on the cast there is a reduction in the thickness of custom-made mouthguards compared to the thickness of mouth-formed mouthguards. The almost optimal thickness of EVA copolymer materials is 4 mm because of its optimal energy absorption and attenuation of transfer of undesirable forces. Greater thickness provides better properties but reduces wearing comfort and acceptance by the athlete (Figure 3) (28-30).

In the protection of the athlete acrylic resin based on elastomers (SR-Ivocap Elastomer®) which is prepared after previous modelling in wax with Ivocap procedure, revealed good results. After polymerization for the duration of 45 min final finishing of mouthguard follows. Ivocap elastomer proved to be a suitable material for fabrication of custom-made mouthguard (Figure 4) (27).

Conclusion

By the use of adequate mouthguards a large reduction in the frequency and severity of athletic dental and periodontal injuries is achieved (1). The loss of teeth are a permanent esthetic and functional disadvantage which is often treated by prosthodontic therapy. The costs of dental restoration caused by sport activities and by loss

of one or more teeth are several times more expensive than the costs of custom-made mouthguard fabrication.

Although by using a stock and mouth-formed mouthguard, a visit to the dentist is avoided, only the use of a custom-made mouthguard is considered to offer the greatest comfort during training and competition, as well as optimal prophylaxis of orofacial injuries. An inadequate and uncomfortable mouthguard is very often not worn, which was confirmed by professional athletes (18,31).

Planning, fabrication and care connected with sport mouthguards should be associated with the dentist. Use of sport mouthguards which, with their technological properties, cannot provide quality protection of the orofacial complex is not recommended. Commercial mouthguards do not encourage athletes to protect their oral health. Custom-made mouthguards are also more suitable for athletes with fixed orthodontic appliances (28).

The intraoral mouthguard is an inevitable part of dental care for professional and amateur athletes. The clinical value of intraoral custom-made mouthguards has been proved. For teeth protection the most important role is provided by the soft layer of the mouthguard which, with its resilience accepts, distributes and attenuates noxious forces (24). For successful use of the mouthguard it is important to predict general as well as the individual requests of each athlete. On the other hand, athletes should be informed about active protection of their oral health (1,19).