A literature review of sports-related orofacial trauma

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This literature review evaluates the significance of dental injuries and their relationship to specific sports activities. Many studies have been published on individual sports or groups of sports but most pertain to specific age groups or levels of competition. Research suggests that many sports that do not require mouthguards should encourage male and female participants to use orofacial protectors.

Athletes, coaches, athletic directors, athletic trainers, parents, and members of the dental community should be aware of how individuals who participate in sporting activities are at risk for dental trauma. Any sport where the potential for dental trauma can exist (such as basketball, soccer, or wrestling) should consider utilizing mouthguards to protect the competitors. The establishment of mouthguard programs for athletes of all ages, genders, and sports may help to reduce the incidence of dental trauma. A sports-related, orofacial/dental trauma reporting system is considered.

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Although mouth protection was introduced to athletes over 100 years ago, only a few sports—including football, boxing, field hockey, ice hockey, and lacrosse—require participants to use mouthguards. Orofacial/dental trauma reporting systems indicate that dental injuries occur in conjunction with athletic activities, particularly the collision and contact sports. Athletes, coaches, and parents continually question the need for protective mouthpieces during sporting activities. As the number of individuals participating in sports has increased, particularly with the enforcement of Title IX, the number of athletes with dental injuries has increased. Not only do male athletes sustain sports-related dental injuries, female sports participants also are being injured in increasing numbers. The tables in this article were constructed to examine the orofacial injury rates of several common sports.

The injury rates cited by the studies in this article vary greatly from region to region. For example, more information pertaining to dental injuries resulting from rugby accidents was available from Australia, where rugby is a dominant national sport, than from any other country in the world. Dental trauma data also were gathered by different methods in many of the cases, making quantitative comparisons difficult. Many surveys were based on prospective questionnaires given to selected groups of athletes and coaches, while other studies collected data from hospital emergency rooms and dental clinics.

With the information provided in this article, dentists should be able to assist their patient-athletes in determining if a mouthguard is recommended when participating in sports.

Orofacial sports injury studies

Because there is no central data-gathering center for sports-related dental injuries, reports concerning orofacial athletic injuries are scattered throughout the dental literature. The tables presented in this article review some of the studies that have been published over the past 20 years. As the number of individuals involved in sports activities increases, so do the number of athletic dental injuries. Orofacial injuries include soft tissue lacerations, chipped or avulsed teeth, and mandibular/maxillary fractures.

Many of the published studies regarding dental injuries and participation in sports are listed in Table 1. Injury rates vary for a number of reasons; some studies looked at specific groups of athletes and a small sample size caused injury rates to appear high. Berg et al reported a high incidence of injury rates due to the number of coaches who reported an injury rather than the true number of injured athletes.

Geographical location resulted in different injury frequencies. For example, Tuli et al reported a high incidence of sports-related dental trauma; alpine skiing accounted for nearly one-third of the oral injuries reported. While Gassner et al confirmed these statistics regarding alpine skiers and maxillofacial trauma, studies by Tanaka et al reported a slightly lower percentage of trauma in Japan. In Israel, Levin et al studied a group of 850 sports participants aged 6–18 and reported a dental injury rate of 27%.

Sample size also affected the results of the reports. Smaller sample groups were affected more by a slight increase in injury reports compared with a larger pool. For example, Takigawa et al used a sample group of 161 and reported an injury rate of 17.9%, while Nishimura et al reported a higher injury rate (24.2%) using a sample size of 184. Other researchers in the same geographical area, whose sample groups ranged from 200 to 1,502, reported injury rates ranging from 9.0–13.8%.

Although athletes may expect to be injured while participating in a specific sport, many of the studies reported that dental/orofacial trauma occurred regularly. The injury rate varied greatly depending upon the ages of the members of the sample group, the sports involved in the study, and the sample group’s geographical location. The studies cited in this article were conducted in the United States, Australia, Finland, Sweden, Italy, Austria, Canada, Hungary, Japan, Brazil, Chile, Singapore, Tanzania, New Zealand, and Great Britain.

Basketball

Basketball accounts for many of the orofacial injuries that are reported to dentists and hospital emergency rooms each year. The enforcement of Title IX in the U.S. has led to a dramatic increase in the number of female collegiate athletes.
This increased participation led to more dental injuries in female competitors. Age-specific studies demonstrate that injury rates in basketball surpass those of collision sports such as football and ice hockey (see Table 2). Dental injury rates among basketball players tended to be lower in countries where basketball is not a major sport than they are in the United States. In a survey of Australian basketball players, Cornwell et al reported a high percentage of oral injuries (23%). Of the 114 players who reported an orofacial injury, 21% stated that a mouthguard was worn at the time of injury. Studies conducted in the U.S. by Garon et al (in 1986) and Soporowski et al (in 1994) reported injury rates of 11.8% and 12.1%, respectively. Of two studies conducted in Finland, a 1988 study reported a basketball injury rate of 5.8%, while a 1995 study by Kujala et al reported a rate of 5.2%. More recently, Nakarnishi et al reported that Japanese basketball players had an injury rate of 2.3%.

Studies that focused on groups of athletes, rather than the general population, showed higher injury rates. Both Ferrari et al and Akemoto et al sampled groups of injured athletes; as a result, the injury rates were greater (36.4% and 11%, respectively) than in studies involving the general population.

A 1989 study by McNutt et al reported that 40% of basketball and baseball players experienced oral trauma; that same year, Maestrello-deMoya and Primosch reported an injury rate of 31% among high school basketball players. A 1995 study of Singapore schoolboys by Teo et al reported an injury rate of 19%. Avulsed teeth were reported as a result of children getting their teeth entangled in basketball nets.

Different surveys indicate that coaches and parents reported that basketball participants experienced dental trauma in high percentages. Berg et al’s 1998 study noted injury rates reported by coaches and parents of 85.4% for boys and 78.4% for girls, while Kvittem et al reported injury rates of 54.7% for boys and 56.3% for girls. In a 1995 study by Diab and Mourino, 19% of parents reported that one of their children experienced a dental injury. Although these percentages appear extremely high, these numbers reflect the number of coaches and parents who reported injuries and not a true count of the number of dental injuries sustained.

Female basketball players also have been shown to be at risk for dental trauma. A 1996 study by Gomez et al found that orofacial injuries accounted for 14% of sports injuries from a sample group. A 1989 study by Morrow et al stated that male collegiate players had an injury rate of 10%, while a subsequent study by Lee-Knight et al reported a very low oral injury rate (0.8%) among elite male basketball players during a short tournament period. Players who wore mouthguards have a significantly lower dental injury rate than those who wore no protection; however, soft tissue injuries and concussions occurred at similar rates, whether or not mouth protection was worn.

These reports show a clear pattern of orofacial injury for basketball competitors. Injury frequencies are higher for age-specific studies demonstrate that injury rates in basketball surpass those of collision sports such as football and ice hockey (see Table 2). Dental injury rates among basketball players tended to be lower in countries where basketball is not a major sport than they are in the United States. In a survey of Australian basketball players, Cornwell et al reported a high percentage of oral injuries (23%). Of the 114 players who reported an orofacial injury, 21% stated that a mouthguard was worn at the time of injury. Studies conducted in the U.S. by Garon et al (in 1986) and Soporowski et al (in 1994) reported injury rates of 11.8% and 12.1%, respectively. Of two studies conducted in Finland, a 1988 study reported a basketball injury rate of 5.8%, while a 1995 study by Kujala et al reported a rate of 5.2%. More recently, Nakarnishi et al reported that Japanese basketball players had an injury rate of 2.3%.

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These reports show a clear pattern of orofacial injury for basketball competitors. Injury frequencies are higher for...
male and female basketball players than for their football counterparts. Although football players are required to wear helmets with face shields and mouthguards at the amateur level (to minimize the risk of dental injury), basketball players have no such mouthguard rule. The authors believe that the dental community should make a strong recommendation for basketball players to use mouthguards to reduce the incidence of dental trauma.

### Baseball and softball

Baseball and softball offer greater possibilities for injury; in addition to the possibility of colliding with other players, athletes also can be hit by either a bat or a batted or thrown ball. Many players require emergency medical treatment for baseball-related orofacial injuries. Softball pitchers often are at risk because of their proximity to the batter and the speed with which a batted ball can return to the pitcher. According to a 1998 study, approximately 75% of coaches reported that at least one of their players had sustained a dental injury, although the actual number of injuries may have been very small.

Table 3 summarizes studies regarding baseball-related orofacial trauma. In studies involving Little League and grade school-age players, Diab and Mourino, Saporowski et al, and Mueller et al reported similar findings regarding orofacial trauma. A 1986 study by Garon et al and a 1989 study by McNutt et al both studied specific groups of athletes and reported significant injury rates among baseball players. More recently, Morrow and Bonci reported a 1.6% injury rate among female collegiate softball players, although this low injury rate may result from underreporting.

Regarding dental trauma, studies involving Japanese players indicate that baseball is a riskier sport than softball. Five different studies reported injury rates among baseball players ranging from 12.7–37%. Softball injury rates among Japanese women were considerably lower; three studies conducted between 1995 and 1999 reported dental injury rates of 2.5%, 5.3%, and 7.0%. A variety of factors could contribute to these low injury rates. Softball is a relatively new sport in Japan, a country where female participation in sports is limited. It is possible that the actual number of female athletes is very small compared to male athletes and that the competitive intensity of female athletes is not yet equal to their male counterparts; as a result, fewer injuries are produced.

Older studies tended to find lower injury rates among baseball players, possibly due to geographical region, underreporting of trauma, and studies that did not look at baseball specifically as a target sport.

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### Table 2. Basketball orofacial injury studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Percentage of injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levin et al (2003)</td>
<td>7% reported basketball-related dental trauma</td>
</tr>
<tr>
<td>Cornwell et al (2003)</td>
<td>23% had orofacial injury; 36.4% of study reported trauma</td>
</tr>
<tr>
<td>LaBella et al (2002)</td>
<td>0.67/1,000 injuries—no mouthguard; 0.12/1,000 injuries—mouthguard</td>
</tr>
<tr>
<td>Nakanishi et al (1999)</td>
<td>2.3% of study reported dental injury</td>
</tr>
<tr>
<td>Kvittem et al (1998)</td>
<td>54.7% of boys, 56.3% of girls reported orofacial injury</td>
</tr>
<tr>
<td>Berg et al (1998)</td>
<td>85.4% of boys’ coaches, 78.4% of girls’ coaches</td>
</tr>
<tr>
<td>Kumatomo et al (1997)</td>
<td>33 cases of tooth avulsion</td>
</tr>
<tr>
<td>Diab and Mourino (1997)</td>
<td>19% reported by parents</td>
</tr>
<tr>
<td>Gomez et al (1996)</td>
<td>14% of injuries reported</td>
</tr>
<tr>
<td>Akemoto et al (1995)</td>
<td>11% oral injury rate in basketball</td>
</tr>
<tr>
<td>Kujala et al (1995)</td>
<td>5.2% of reported total injuries</td>
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<tr>
<td>Teo et al (1995)</td>
<td>19% Singapore schoolboys</td>
</tr>
<tr>
<td>Flanders and Bhat (1995)</td>
<td>18.3/100,000 of Illinois sample</td>
</tr>
<tr>
<td>Saporowski et al (1994)</td>
<td>12.1% of schoolchildren</td>
</tr>
<tr>
<td>Lee-Knight et al (1992)</td>
<td>0.8% of male players; 1.3% of female players</td>
</tr>
<tr>
<td>Morrow et al (1991)</td>
<td>10.0% of male collegiate players</td>
</tr>
<tr>
<td>Morrow and Bonci (1989)</td>
<td>7.5% of female collegiate players</td>
</tr>
<tr>
<td>Maestrello-deMoya and Primosch (1989)</td>
<td>31% of high school players</td>
</tr>
<tr>
<td>McNutt et al (1989)</td>
<td>40% of injuries in baseball and basketball</td>
</tr>
<tr>
<td>Sane (1988)</td>
<td>5.8% of sample</td>
</tr>
<tr>
<td>Bhat and Li (1987)</td>
<td>3.38% hospital emergency room treatment</td>
</tr>
<tr>
<td>Garon et al (1986)</td>
<td>11.8% of sample</td>
</tr>
</tbody>
</table>

### Table 3. Baseball and softball orofacial injury studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Percentage of injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mueller et al (2001)</td>
<td>21.3% of injuries involving ball were dental</td>
</tr>
<tr>
<td>Kanoh et al (1999)</td>
<td>22% baseball trauma; 7% softball trauma</td>
</tr>
<tr>
<td>Nakanishi et al (1999)</td>
<td>25.2% of injuries from baseball; 5.3% of injuries from softball</td>
</tr>
<tr>
<td>Sakamoto (1999)</td>
<td>High school trauma reported</td>
</tr>
<tr>
<td>Iida et al (1998)</td>
<td>37% baseball injuries</td>
</tr>
<tr>
<td>Berg et al (1998)</td>
<td>75.6% boys baseball; 73.6% girls softball</td>
</tr>
<tr>
<td>Diab and Mourino (1997)</td>
<td>17% were baseball-related</td>
</tr>
<tr>
<td>Tanaka et al (1996)</td>
<td>12.7% trauma from baseball</td>
</tr>
<tr>
<td>Akemoto et al (1995)</td>
<td>22% dental trauma from baseball; 2.5% trauma from softball</td>
</tr>
<tr>
<td>Saporowski et al (1994)</td>
<td>21.6% baseball-related</td>
</tr>
<tr>
<td>Tanaka et al (1992)</td>
<td>11.2% baseball fracture cases</td>
</tr>
<tr>
<td>Morrow and Bonci (1989)</td>
<td>1.6% were softball-related</td>
</tr>
<tr>
<td>McNutt et al (1989)</td>
<td>40% baseball- and basketball-related</td>
</tr>
<tr>
<td>Garon et al (1986)</td>
<td>12.9% baseball-related</td>
</tr>
<tr>
<td>Bhat and Li (1987)</td>
<td>6.68% hospital emergency cases</td>
</tr>
<tr>
<td>Nicholas (1980)</td>
<td>2.2% New Zealand schoolchildren</td>
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</tbody>
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Although serious injuries have been reported in softball, studies indicate that softball demonstrates a much lower rate of dental trauma than baseball. The authors feel that a recommendation of helmets with the addition of a mouthguard, in a fashion similar to football, should be made to protect baseball and softball players.

**Soccer**

The increase in participation in soccer among all age groups has resulted in an increased number of dental injuries. The success of U.S. teams in recent World Cup and Olympic competition has increased interest and participation in all parts of the country. The enforcement of Title IX has made it possible for female athletes to compete both on the field and in the classroom. 4

Soccer orofacial injury rates were similar among male and female athletes (see Table 4).3,4,9 Berg et al showed coaches reporting soccer injury rates of 68.3% for boys and 63.2% for girls, while Kvittem et al reported injury rates of 25.6% for boys and 27.3% for girls.4,9 The significant increase in observed injury rates could be the result of increased soccer participation or possibly a more aggressive reporting system by coaches and parents. In the 2003 study by Levin et al, 6% of the 456 individuals who reported playing soccer sustained dental trauma.4

Again, older, collegiate athletes exhibited almost negligible injury rates compared to younger age groups. Two separate studies by Morrow et al reported injury rates of 2.6% for male soccer players and 3.1% for females.3,4,9 Six other studies reported injury rates ranging from 2.8–13.8%.3,8,10,14,15,16

Small sample sizes resulted in higher injury rates. Six studies with small sample sizes reported injury rates ranging from 9–20%.3,8,10,14,15,16 In a study that examined 268 injuries sustained by athletes 5–13 years old, Nicholas reported an injury rate of 3% over a six-month period.37

Studies that sampled groups of injured athletes only tended to report higher injury percentages compared to dental trauma percentages within the general pool of soccer players.3,8,4,9 Emshoff et al reported that 8.9% of sports-related maxillofacial fractures occurred to soccer players.3,8 A study conducted one year later stated that 81.8% of the soccer athletes did not think that mouthguards were necessary for the sport.48

| Table 4. Soccer orofacial injury studies.3,8,10,14,15,16,18,41,42,45-47,51,55-60 |
| Author | Percentage of injuries |
| Levin et al (2003) | 6.0% reported soccer-related dental trauma |
| Tuli et al (2002) | 8.0% of denofacial trauma |
| Kanoh et al (1999) | 18% of players reported injury |
| Nakanishi et al (1999) | 13% of group had injury |
| Iida et al (1998) | 10.3% reported injury |
| Kvittem et al (1998) | 25.6% of boys and 27.3% of girls reported orofacial injury |
| Berg et al (1998) | 68.3% of boys’ coaches; 63.2% of girls’ coaches reported an injury |
| Yamada et al (1998) | 32.3% Japanese schoolchildren |
| Diab and Mourino (1997) | 11% reported by parents |
| Emshoff et al (1997) | 8.9% mandibular fractures |
| Tanaka et al (1996) | 10.8% had oral injury |
| Akemoto et al (1995) | 9% suffered dental trauma |
| Kujala et al (1995) | 2.8% of reported soccer injuries |
| Teo et al (1995) | 20.0% Singapore schoolboys |
| Tanaka et al (1992) | 10.1% of maxillofacial sports fractures |
| Morrow et al (1991) | 2.6% for male collegiate athletes |
| Morrow and Bocci (1989) | 3.1% of female collegiate athletes |
| Sane and Ylipaavelniemi (1988) | 4.5% of injury rate in Finland |
| Sane and Ylipaavelniemi (1987) | 6.4% of injuries were dental |
| Nysether (1987) | 20% of all injuries were dental |
| Hill et al (1985) | 109 of 790 of injuries reported were dental (13.8%) |
| Nicholas (1980) | 3.0% New Zealand schoolchildren |

| Table 5. Ice hockey, field hockey, and lacrosse orofacial injury studies.3,8,10,14,15,41,45-47,49,55-64 |
| Author | Percentage of injuries |
| Lahti et al (2002) | 50% of damaged teeth were maxillary central incisors |
| Nakanishi et al (1999) | 1.5% reported dental injury |
| Benson et al (1999) | dental injury rate 9.9 times greater for half shields |
| Akemoto et al (1995) | 1.6% had dental injury |
| Kujala et al (1995) | 7.1% of reported ice hockey injuries |
| Soperowski et al (1994) | 12.7% hockey/lacrosse/field hockey |
| Lee-Knight et al (1992) | 1.3% injury rate for field hockey players |
| Morrow et al (1991) | 2.9% for male collegiate athletes |
| Morrow et al (1991) | 9.8% reported in collegiate hockey |
| Morrow et al (1989) | 2.3% for female athletes |
| Sane and Ylipaavelniemi (1988) | 8.9% of hockey injuries |
| Sane et al (1988) | 11.5% of injuries were dental |
| Bolhuis et al (1987) | 20% of sample reported dental injury |

Although the number of soccer dental injuries reported is variable, the authors believe that a recommendation should be made for the use of mouthguards in soccer. **Ice hockey, field hockey, and lacrosse**

Ice hockey, field hockey, and lacrosse all require their players to wear mouthguards; even so, studies report that these sports still result in orofacial trauma. The trauma may result from the fact that unlike football, these three sports use both a stick and a solid ball or puck.

Studies conducted between 1988 and 1995 reported ice hockey dental injury rates significantly higher than football injuries.
dental injury rates (see Table 5). Benson et al reported in 1999 that players who wore only half-face shields were approximately 10 times more likely to sustain a dental injury than players wearing full-face shields. In 2002 a sample of ice hockey players, Lahti et al found that dental injuries accounted for 11.5% of all reported hockey injuries. Of these dental injuries, 50% of the damaged teeth were maxillary central incisors.

In Japan, where ice hockey is not the most popular sport, a 1995 study reported an injury rate of 1.5%; four years later, Nakashishi et al reported an injury rate that was almost identical (1.6%).

Orofacial injury rates were lower for field hockey players than for ice hockey players. A 1987 study by Bolhuis et al sampled 279 international field hockey players competing in three championship tournaments and noted that 20% had sustained a dental injury. Studies by Morrow et al reported a 2.9% injury rate for male field hockey players and a 2.3% injury rate for female players. Lee-Knight et al studied athletes competing in a national tournament and reported a low injury rate of 1.3%. Soporowski et al sampled ice hockey, lacrosse, and field hockey players and reported a combined injury rate of 12.7%.

Although ice hockey, field hockey, and lacrosse require mouthguards and helmets with face shields for men, orofacial injuries from these sports are reported at a higher rate than those incurred in football, a sport that requires similar safety equipment. It is possible that some ice hockey players do not comply with the mouthguard rule and are injured as a result.

### Bicycle

The Bicycle Helmet Safety Institute estimates that approximately 85 million Americans ride a bicycle. Approximately 540,000 bike riders end up in the hospital emergency room every year. The orofacial injury rate for bicycle riders has remained relatively stable over the past 20 years. Bicycle helmets are encouraged but using them for protection from dental injuries has not been a major issue.

The majority of reports found higher rates of dental trauma among bicycle riders than among participants in most other sports (see Table 6). The speed at which the rider is traveling and the use of toe clips has put bicycle riders at risk for orofacial trauma. In a study of Australian hospital cases, Acton et al found that 39.5% of that sample were the result of bicycle accidents. Blinkhorn found that 30% of dental trauma in a group of adolescents in North West England resulted from bicycle accidents. In 1997, Emshoff et al reported that bicycle ride accidents accounted for over 25% of sports-related orofacial fractures in the U.S.

### Table 6. Bicycle orofacial injury studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Percentage of injuries</th>
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</thead>
<tbody>
<tr>
<td>Levin et al (2003)</td>
<td>6.0% reported bicycle-related dental trauma</td>
</tr>
<tr>
<td>Iida and Matsuys (2002)</td>
<td>26% of facial fractures were due to bicycle accidents</td>
</tr>
<tr>
<td>Tuli et al (2002)</td>
<td>18.7% of dentofacial trauma (mountain biking 4.9%)</td>
</tr>
<tr>
<td>Gabris et al (2001)</td>
<td>13% of injuries in bicycle accident</td>
</tr>
<tr>
<td>Blinkhorn (2000)</td>
<td>30% of dental trauma bicycle/sports</td>
</tr>
<tr>
<td>Marcenes et al (2000)</td>
<td>19.2% of dental trauma bicycle-related</td>
</tr>
<tr>
<td>Linn et al (1998)</td>
<td>dental injury 9.9 times greater for helmets</td>
</tr>
<tr>
<td>Lombardi et al (1998)</td>
<td>9% of hospital trauma cases</td>
</tr>
<tr>
<td>Emshoff et al (1997)</td>
<td>25.4% of mandibular fractures</td>
</tr>
<tr>
<td>Acton et al (1996)</td>
<td>39.5% of hospital cases</td>
</tr>
<tr>
<td>Thompson et al (1996)</td>
<td>6.6% oral injury</td>
</tr>
<tr>
<td>Onetto et al (1994)</td>
<td>9% of reported dental trauma</td>
</tr>
<tr>
<td>Soporowski et al (1994)</td>
<td>17.2% were bike/scooter related</td>
</tr>
<tr>
<td>Bhat and Li (1987)</td>
<td>13.99% of hospital emergency dental injuries</td>
</tr>
<tr>
<td>Hill et al (1985)</td>
<td>5.6% of reported injuries dental</td>
</tr>
<tr>
<td>Nicholas (1980)</td>
<td>13% New Zealand schoolchildren</td>
</tr>
</tbody>
</table>

A 1994 study of school-age children in Massachusetts, Vermont, Connecticut, and Maine reported that bicycle/scooter accidents were responsible for 17.2% of dental trauma incurred. Benson et al reported in 1999 that players who wore only half-face shields were approximately 10 times more likely to sustain a dental injury than players wearing full-face shields.
Rugby injury studies

Most rugby studies have been performed in Australia, where rugby is the country’s major sport. Rugby is a collision sport that, unlike football in the U.S., does not require protective equipment. The reported dentofacial injury rates for rugby are similar to those of U.S. football from the period before facemasks and mouthguards were mandated (see Table 7).

Yamada et al reported that 56.5% of Japanese high school students who played rugby suffered dental injury as a result. Another Japanese study by Kanoh et al investigated 68 maxillofacial fracture cases and found that 28% of these patients sustained their injuries while playing rugby. Hill et al studied an emergency department in the U.K. over a 12-month period and noted that 26% of maxillofacial injury patients required treatment due to rugby accidents.

The following studies were conducted in Japan. A 1996 study by Tanaka et al surveyed 102 athletes with maxillofacial injuries and reported that 24 (23.5%) were rugby players. Three years later, Nakanishi et al found that of 131 athletes who had suffered a maxillofacial injury, 25 (19.1%) were the result of a rugby accident. That same year, Iida et al reported that of 146 patients who had sustained an orofacial injury, 13.8% had done so while playing rugby. Finally, Akemoto et al studied 122 athletes and noted that 15 (12%) had incurred a maxillofacial injury while playing rugby.

A 1999 study by Carson et al examined an elite female rugby team over a 12-month period and determined that the team had 50% fewer injuries than a comparable men’s rugby squad. Although this report was not specific about orofacial trauma, the authors stated that injuries occurred at a rate approximately equal to those sustained by women playing other contact and collision sports, specifically soccer and gymnastics.

A 1996 study by Jolly et al reported on four groups of rugby players (a total of 2,611 players) in Victoria, Australia, noting that 25–31% had experienced a dental injury; the injury rate varied by age group. The same study also noted the players’ willingness to use mouthguards even though the devices were not required. Some orofacial injuries did occur while players were wearing mouthguards. Hill et al studied an emergency department in the U.K. over a 12-month period and noted that 26% of patients with maxillofacial injuries were the result of rugby accidents. The authors stated the need for improved safety standards to prevent orofacial trauma.

Muller-Bolla et al polled 36.4% of U.S. rugby team reported dental injury; 33.3% of Australian rugby team reported dental injury. Hill et al (1985) 206 of 790 (26%) reported dental injury.

Carson et al (1999) women’s rugby had 50% fewer injuries than men’s rugby

Kanoh et al (1999) 28% had oral trauma

Nakanishi et al (1999) 19.1% had dental injury

Yamada et al (1998) 56.5% Japanese high school students

Iida et al (1998) 17.8% of players reported injury

Chapman and Nasser (1996) 13–15% sport-related


Tanaka et al (1996) 23.5% had dental injury

Akemoto et al (1995) 12% of sample reported injury

Chapman and Nasser (1993) Just under 50% experienced dental injury

Tanaka et al (1992) 24.7% of traumatic fracture patients

Jennings (1990) 71.9% reported injury

Chapman (1990) 40% of British rugby team reported dental injury;

Tanaka et al (1990) 206 of 790 (26%) reported dental injury

Chapman (1998) 33.3% 1984 Wallabies; 60.7% 1984 Great Britain Touring Team

Nicholas (1980) 6.7% New Zealand schoolchildren

Table 7. Rugby orofacial injury studies.

<table>
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<tr>
<th>Author</th>
<th>Percentage of injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muller-Bolla et al (2003)</td>
<td>25.97% reported trauma of the lower or middle part of the face</td>
</tr>
<tr>
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<td>women’s rugby had 50% fewer injuries than men’s rugby</td>
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Table 7. Rugby orofacial injury studies.

Regardless of geographical residence, mouthguards could protect rugby players from orofacial trauma.

Football

In the 1950s, it was reported that approximately 54% of all football injuries were orofacial injuries. Through the use of facemasks and mouthguards, the amount of dental injuries among football players has been reduced. Regardless of geographical residence, mouthguards could protect rugby players from orofacial trauma.

In a study of registered American football, bandy, basketball, and handball players in Finland, Sane and Ylipaavelniemi found a dental accident rate of 1.4% among football players. By comparison, Flanders and Bhat sampled Illinois high school football players and calculated a dental injury rate of 1.4:100,000. Mouthguards molded from latex were introduced to football programs on a trial basis until 1962, when they became mandatory in high schools. The National Collegiate Athletic Association (NCAA) adopted a mandatory mouthguard rule in 1973. From a historical standpoint, even professional football players have had...
dental problems. In 1983, Randell reported that of 34 players on one team, 18 (53%) exhibited untreated trauma, dental caries, periodontal problems, and third molar complications. Even though finances were not an issue, it appeared that these athletes had overlooked their dental condition due to a lack of awareness about dental health. The highest dental injury rate (18.3%) appeared in a 1986 study by Iida et al. 

The greatest concern today in football is the serious problem of concussions. Health care professionals are unclear regarding the mechanism that causes concussions and how to make a definitive diagnosis. The role mouthguards play in the prevention of concussions is a controversial issue, particularly among quarterbacks, who appear to be at greater risk for sustaining a concussion.

### Other sports

Table 8 lists other sports activities that have reported various percentages of oral trauma among their participants. Most of these sports are low profile but even though the participants do not receive the television coverage, publicity, or large audiences of higher-profile sports, accidents still occur with some regularity.

Alpine skiing accidents can lead to extremely traumatic injuries; a 2000 study of Austrian sports participants (involving 794 patients treated over an eight-year period) reported maxillofacial fractures. It was estimated that dental injuries make up 2% of skiing trauma; luxations, fractured tooth structure, avulsions, soft tissue damage, and fracture of facial bones were the reported sequelae of such accidents. Injuries generally resulted from falls, collisions with other skiers, or skiers making contact with their own equipment. Tuli et al reported that skiing accidents were responsible for 31.8% of the dentofacial trauma that resulted from sports activities. The sample group was located in Austria; as a result, skiing was the predominant sport in this study.

While the study conducted in Austria involved more than 9,000 skiers, studies conducted in Japan used relatively small sample groups, resulting in skiing-related orofacial injury rates ranging from 5.5–23.6%.

Gymnasts do not demonstrate a large dental injury rate but accidents do occur. Soporowski et al found that a small percentage of athletes sustained orofacial trauma, while Tuli et al reported a low injury rate (2.1%) in the group that was surveyed. These injuries are particularly unique since gymnasts do not come into physical contact with other competitors or projectiles such as balls, pucks, or bats. Bayliss and Bedi reported that most accidents that resulted in dental injury involved more advanced level gymnasts and most of the injuries occurred during practice rather than competition.

Martial arts exhibit a small but significant percentage of dental trauma. Studies conducted between 1995 and 1999 reported that injuries occurred among participants in judo, karate, and kendo. Since physical contact with a competitor is the primary focus of these sports, some trauma might be expected.

Boxing and wrestling resulted in a significant number of dental injuries. Kvittem et al found that the chance of one competitor sustaining a dental injury during a season was 72.3%, while Persson and Kiliaridis discovered that more than 50% of the wrestlers they interviewed had experienced some oral trauma. A sample of Singapore schoolboys reported that boxing and wrestling resulted in 33% of dental injuries. Wrestlers, soccer players, and basketball players wearing orthodontic appliances also were more likely to suffer an injury.

Volleyball generally demonstrated a low rate of dental trauma. Morrow et al and Kujala et al both reported low rates for dental injuries.
injured over the course of a season.\textsuperscript{9} Volleyball appears to be less risky than most other competitive sports regarding orofacial injuries.

According to the 1980 study by Nicholas et al., swimming had a surprisingly high injury rate.\textsuperscript{50} It was not clear if these swimmers were recreational or competitive; for example, water polo players might expect to experience a high injury rate.

So-called “extreme” recreational activities such as skateboarding and snowboarding also have demonstrated significant rates of dental injury. A 1999 study of Japanese snowboarders reported a 27.3% dental injury rate; by comparison, a 1996 study by Wakabayshi et al. found that 14% of the sample group experienced some type of dental trauma while snowboarding.\textsuperscript{55}

Contact sports (including the martial arts) should consider the use of mouth protectors to minimize the chance of orofacial injury. Non-contact recreational sports like skiing, gymnastics, skateboarding, and snowboarding also demonstrate a risk for dental trauma. Using a mouthguard for these activities may benefit participants.

Orofacial injury site studies

Individuals participating in sports activities may be at risk for dentofacial trauma. The literature indicates that the maxillary central incisors are injured more frequently than any other teeth (see Table 9).\textsuperscript{22,25,27,29,37,39,42,57} Other non-sports events, such as falls, automobile accidents, fighting, and work injuries, also can result in trauma to the maxillary front teeth.

The rate of injury is relatively similar regardless of the sport involved or the geographic region. The countries listed in Table 9 include Norway, Finland, Hungary, Italy, New Zealand, Singapore, Sweden, and the U.S.; the sports involved include soccer, football, bandy, ice hockey, wrestling, and basketball.

The use of a mouthguard may protect the maxillary front teeth from injury. Labella et al. reported a significant difference in the injury rates of basketball players who wore mouthguards compared with players who did not.\textsuperscript{38} Football has demonstrated a dramatic decrease in dental injuries with the use of mouthguards and helmets with facemasks. The use of mouthguards in all sports would reduce the chance of dental injury for an athlete.

Mouthguard historical timeline

The first reported mouthguard was made by Woolf Krause in 1892.\textsuperscript{86} Dental literature does not mention mouthpieces again until 1915, when professional boxer Ted “Kid” Lewis is reported to have used a mouthguard during a championship bout. On February 7, 1921, Lewis fought Jack Britton, whose camp protested Lewis’ use of a mouthpiece. Shortly after the match, boxing officials declared mouthguards illegal; however, officials later changed their ruling and mouthguards have become a part of regular boxing equipment.\textsuperscript{86}

In the 1950s, several dental societies started making mouthguards for football teams. Prior to this, approximately 50% of all football injuries were dental. The National Alliance Football Rules Committee adopted a mandatory mouthguard rule for high schools and junior colleges in 1962 and the NCAA added mouthguards to the list of mandatory football equipment in 1973.\textsuperscript{86}

USA Hockey, the national governing body for the sport of hockey in the U.S., adopted a mandatory mouthguard rule in 1975. Today, most amateur levels of ice hockey, including youth leagues, high school, and college, require the use of mouthguards; however, it is the authors’ experience that many professional players refuse to wear intraoral mouth protection.

In 1983, a group of dentists who had worked with athletes and mouthguards at amateur and professional levels founded the Academy for Sports Dentistry. This organization was created for individuals who were interested in sports and dentistry to exchange ideas, stimulate research, and promote the concept of orofacial protection through the use of mouthguards. This group has expanded and now has many international members.

As of 2003, football, boxing, ice hockey, field hockey, and lacrosse are the only sports in the U.S. that require players to use a mouthguard. For sports where a dental injury might occur, such as rugby and basketball, athletes use mouth protection on a limited, voluntary basis.

Summary

Studies show that sports are the cause of many dental injuries and that trauma rates vary for many reasons. Different age groups exhibit different injury rates, collision sports have different rates than contact sports, and the various levels of competition (that is, professional and amateur) result in a wide range of facial injury rates. Different cultures place more emphasis on certain sports; for example, Australia emphasizes rugby while the U.S. has more intense competition in football. As a result, these studies note higher injury rates for these sports. Over time, injury rates have decreased in some sports such as football and ice hockey due to the requirement and improvement of protective equipment, such as facemasks and mouthguards.

In some cases, injury rates have increased as more individuals participate in a specific sport. For example, Title IX has increased the participation of female athletes in the United States at all levels of competitive and recreational activities.

Mandibular fractures also occur with some frequency in high-velocity sports, such as bicycle riding and alpine skiing; snowboarding and skateboarding are relatively new sports that also account for orofacial trauma.

A far-reaching, recording mechanism has been recommended to create a more

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### Table 9. Teeth injured most frequently in sports activities\textsuperscript{22,25,27,29,37,39,42}

<table>
<thead>
<tr>
<th>Author</th>
<th>Percentage of injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabris et al (2001)</td>
<td>85.87% maxillary central incisors</td>
</tr>
<tr>
<td>Lombardi et al (1998)</td>
<td>87% maxillary permanent incisors</td>
</tr>
<tr>
<td>Borsen and Holm (1997)</td>
<td>75% maxillary incisors</td>
</tr>
<tr>
<td>Petti and Tarsitani (1996)</td>
<td>62% maxillary central incisors</td>
</tr>
<tr>
<td>Petti et al (1996)</td>
<td>74.6% maxillary central incisors</td>
</tr>
<tr>
<td>Teo et al (1995)</td>
<td>64.8% maxillary incisors damaged</td>
</tr>
<tr>
<td>Nysether (1987)</td>
<td>45% of injuries affected maxillary anterior teeth</td>
</tr>
<tr>
<td>Nicholas (1980)</td>
<td>72.4% maxillary central incisors</td>
</tr>
</tbody>
</table>
significant database. Whether this recording is performed at a national or an international level, it could provide more accurate information for anyone looking for information about a specific sport. Incidents could be recorded on an ongoing basis rather than retrospectively, making the data more reliable and accurate.

Comparing injury statistics can be difficult as there is no uniform system for reporting the number of injuries. Some studies report injuries per 1,000, 10,000, or 100,000 incidents, while other studies report injuries based on percentages of the sample group; the small size of the target population means that these numbers may be inaccurate. Conversely, these statistics may be lower than expected because the athletes affected may not report all of their injuries.

The importance of orofacial protection should be stressed to the general population by members of the dental profession. Mouthguards have been shown to reduce the number of dental injuries. Mouthguard programs, as fee-for-service entities or voluntary public service projects, benefit both the athletes and the dentists involved. These programs promote dentistry and enhance the image of the profession in the community.

**Author information**

Dr. Kumamoto is a clinical associate professor, College of Dentistry, University of Illinois at Chicago. Dr. Maeda is a professor and Head, Division of Interdisciplinary Dentistry, Osaka University, Japan.

**References**


51. Sakamoto B. In high school play, a livelier soft ball may be adding insult to injury. Chicago Tribune. May 13, 1999.


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1. This study encompassed the past
A. 10 years.
B. 20 years.
C. 30 years.
D. 40 years.

2. Which of the following sports was not included in this review?
A. Bicycling
B. Skiing
C. Tennis
D. Gymnastics

3. A mouthguard should be recommended for any athlete participating in a sport in which dental trauma can occur. The establishment of mouthguard programs for all ages, genders, and sports will eliminate the incidence of dental trauma.
A. Both statements are true.
B. The first is true; the second is false.
C. The first is false; the second is true.
D. Both statements are false.

4. Over the past 30 years there has been an increase in the number of individuals participating in sports. What is the primary reason for this increase?
A. Tripling of school sports budgets
B. A dramatic increase in university physical education majors
C. Affirmative action
D. Enforcement of Title IX

5. Mouth protection was offered to athletes more than 150 years ago. Today most sports mandate the use of mouthguards.
A. Both statements are true.
B. The first is true; the second is false.
C. The first is false; the second is true.
D. Both statements are false.

6. Which teeth are injured most frequently?
A. Maxillary lateral incisors
B. Mandibular central incisors
C. Mandibular lateral incisors
D. Maxillary central incisors

7. The data gathered in this literature review were accumulated by many different methods. These methods include:
1. Surveys given to selected groups of athletes
2. Data from hospital emergency rooms
3. Surveys given to selected groups of coaches
4. Data from dental clinics
   A. 1 and 3 only
   B. 2 and 3 only
   C. 1, 2, and 4 only
   D. 1, 2, 3, and 4

8. There now is a central data-gathering center for sports-related dental injuries. This makes it easier to make quantitative and qualitative comparisons.
A. Both statements are true.
B. The first is true; the second is false.
C. The first is false; the second is true.
D. Both statements are false.

9. The orofacial injuries in the studies reviewed included:
1. Maxillary fractures
2. Chipped or avulsed teeth
3. Mandibular fractures
4. Soft tissue lacerations
   A. 1, 2, and 3 only
   B. 2, 3, and 4 only
   C. 1, 3, and 4 only
   D. 1, 2, 3, and 4

10. Age-specific studies indicate that the orofacial injury rate of which sport surpasses the injury rate of collision sports such as football and ice hockey?
A. Bicycling
B. Skiing
C. Basketball
D. Rugby

11. Which member of a football team may have the highest risk for sustaining a concussion?
A. Center
B. Linebacker
C. Running back
D. Quarterback

12. In one study of basketball players who wore mouthguards, there was a significantly lower dental injury rate than among players who wore no protection at all. It also was found that the wearing of mouthguards lowered the incidence of soft tissue injuries and concussions.
A. Both statements are true.
B. The first is true; the second is false.
C. The first is false; the second is true.
D. Both statements are false.

13. In what year did the NCAA adopt the mandatory mouthguard rule, which, when combined with facemasks, has reduced the dental injury rate in football to almost zero?
A. 1958
B. 1962
C. 1973
D. 1979

14. In which sports were players more likely to suffer an injury if they were wearing orthodontic appliances?
A. Baseball, softball, and hockey
B. Skiing, gymnastics, and volleyball
C. Wrestling, soccer, and basketball
D. Football, rugby, and boxing

15. As of 2003, which sports in the U.S. required the use of mouthguards?
A. Football, boxing, ice and field hockey, lacrosse
B. Baseball, softball, basketball, wrestling
C. Rugby, wrestling, volleyball, skiing
D. Swimming, bicycling, martial arts, soccer