A Technique for Fabricating Modern Athletic Mouthguards

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Abstract

The prevention and treatment of orofacial trauma is now a very important part of the general practice.\textsuperscript{1,2} Children as well as adults are participating more in events where the probability of trauma is apparent. Attendance at health clubs and gymnasiums is on the rise. With the increase in sports participation comes an increase in orofacial injuries.\textsuperscript{3} The general population is taking its health more seriously. Athletic participation is on the rise, and Title IX\textsuperscript{4} has introduced increased female participation at all levels. This only increases the possibility that our patients will present themselves in our offices with the need for trauma treatment and also our opinions on the methods of preventing such traumatic experiences.\textsuperscript{5}

The field of sports and trauma dentistry has come a long way in recent years. Dentistry is now represented on various medical commissions and organizations as a viable component of the total package of prevention and treatment of orofacial injuries. Internationally, dentistry is represented on the International Olympic Committee’s Medical Commission and the International Ice Hockey Federation Medical Commission. In 1998, the International Society for Dentistry, Sport and Trauma was introduced as the need for international trauma dentists increased. In the United States, the Academy for Sports Dentistry was continuing to grow and provide insight on trauma treatment and prevention.

The general dentist is now being asked by their patients for their opinions on prevention of athletic injuries. In the past, patients would feel comfortable going to the local sporting goods stores to obtain mouth/dental guard protection. This is no longer the case. As the population becomes more and more educated on injury prevention and the...
availability of proven methods of prevention, the general dentist will be called on to provide a more viable responsible solution for orofacial trauma prevention. The medical/dental literature now provides many references for the probability and treatment of trauma.6-12

The numbers, incidences and severity of trauma leads us to contemplate ways of preventing such injuries. Presently, the use and acceptance of preventive mouthguards is gaining on the general dentist's list of priorities. More general dentists are now providing custom-made mouthguards to their patients. However, there are still a significant number of dentists who do not provide this service to their regular patients. Dentist's knowledge and attitudes toward providing protective mouthguards is well documented. Parental perceptions of mouthguards is an important issue that dentists needs to identify and manage.13,14

Overcoming objections of cost, custom-made vs. store-bought, vacuum vs. pressure, and availability is critical to the education of dentists, staff and patients.15 Patient education is essential to the success of trauma prevention. The dental hygienist here may play a critical role in this education during routine periodontal treatment.16

There are basically three types of athletic mouthguards presently available, all significantly different in fit, comfort and acceptance. Type I is the stock mouthguard available at sporting goods stores. These are the least desirable and acceptable. There is no attempt at fit. Remove from package and place in mouth. Type II refers to the common boil and bite mouthguard. These are also mostly of the store-bought variety and some attempt at fit is made by boiling the mouthguard and trying to mold it to the teeth. The instability and uneven distribution of material does not lend themselves to proper fit and protection. In a study by Dr. Andrew Greasley on the difference between various types of mouthguards, the custom-made mouthguards all performed better than the "boil and bite type which afforded only slightly more protection than no mouthguard at all."17 Chapman and McNutt reported many occurrences of injuries while wearing the over the counter Types I and II variety of mouthguards.18,19 In literature reviews by the author, there were no published data and support found for stock and boil and bite mouthguards after 1980. The literature makes it very clear that only custom-made mouthguards should be offered to patients.

The literature cites occurrences of injuries while wearing noncustom-made mouthguards.

Chapman in 1991 reported as high as 36 percent of the athletes who wore mouthguards while playing at the Second
Rugby World Cup, sustained some type of orofacial injury. McNutt in 1989 reported that of the 1,470 surveyed American Football players, 52 athletes were injured wearing mouthguards, and 53 were injured without a mouthguard. The injury rate is the same for those wearing mouthguards and those who were not wearing mouthguards. They were the same as wearing nothing.

There are two types of Type III custom-made mouthguards presently available, those made with vacuum machines and those made by pressure machines. The difference between the old conventional vacuum machines and the new vacuum and pressure machines are significant and should be addressed. The internal adaptation difference is noteworthy due to the amount of heat and pressure/suction variances in each machine. While contemplating purchasing these machines, the internal adaptation for fit should be the prime focus of attention. A mouthguard will not be as protective if it does not fit properly. The better the fit, the better the protection, acceptance, and compliance.

Figures 1a-f. Note the difference in internal adaptation when comparing the old conventional vacuum machine to the newer pressure or vacuum machines. One can easily see the adaptation from their machine by making a mold from a 3 mm sheet of ethylene vinyl acetate material. Take out the original model and pour stone into the ethylene vinyl acetate material. The result will show you the adaptation of your machine. From there, decisions can be made on purchasing the newer varieties of vacuum machines or investing in the state of the art pressure machines.

The role of the dentist in trauma prevention is patient education, diagnosis and designing custom-made mouthguards, then choosing whether to fabricate them in office or send them to qualified laboratories. Minimum thicknesses and extensions are critical for trauma prevention. The suggested minimal thicknesses are labially 3 mm, palatal 2 mm, and occlusally 3 mm. The mouthguards are designed according to the sport played, age of the athlete, and past history of trauma. The material of choice is ethylene vinyl acetate with a shore hardness of 80.

There are four parts to the fabrication of custom made mouthguards.

- Impression
- Fabrication
- Trimming and polishing
- Placement and occlusal equilibration

Figures 2a-e. The impression is critical to the end result. Similar to any restorative procedure requiring an impression; the better the impression, the better the appliance. It has been the author's experience that an excellent
method for impressions for mouthguard appliances is the Accu-Dent System II. The Accu-Dent multicolloid impression systems eliminate the need for custom-impression trays, allowing you to create master casts in a more efficient and profitable manner. The impression gels are formulated in two viscosities, a light-bodied syringe gel that captures soft tissues and a heavy body tray gel for hard tissue. Ideal for athletic custom-made mouthguards, the Accu-Dent System II can also be used for partials, immediate dentures, orthodontics, and splints. The light-bodied syringe gel is applied with a special tip to capture detail while eliminating air bubbles.

Figure 3. Once the impression has been taken, immediate pour-up with a hard die stone is recommended. Care is taken to capture all vestibular borders. A large base is not necessary as it will be taken off while trimming the model.

Figures 4a-e. After the model has become hard and set, usually about 45 minutes, mark the highest margins of the vestibular border with a pencil for reference during trimming. At the model trimmer, remove the excess stone carefully to these borders. By including these vestibular borders, the mouthguard will have more retention due to increased surface adaptation and will also help protect the alveolar bone for further protection from trauma.
**Figure 7a.**

**Figures 7a and b.** A sheet of ethylene vinyl acetate is placed in a disc positioning ring. A trimmed model is placed slightly off center toward the lingual.

**Figure 8.** A clamping ring locks sheet into place.

**Figure 9a.**

**Figures 9a, b and 10.** Heater is used to obtain formable consistency.

**Figure 9b.**

**Figure 10.**

**Figure 11.** Pressure is used on the first layer and timing is crucial to maintain pressure.

**Figure 12.** A proper cool-down period prevents distortion.

**Figure 5a.** Once the model has been properly trimmed and dry, it must be lubricated to allow easy separation after fabrication. The author's lubricant of choice is orthodontic model soap. Soak the model in the soap for approximately one hour, then dry and polish with a dry towel. The model is now lubricated for the life of the model.

The model is now ready for the fabrication of the mouthguard. This method of bilamination by thermo-pressure was previously described in 1999. There have been a few changes and additions to the fabrication process.

**Figures 6a-c.** Note this process is not (suck down) vacuum. It is positive pressure. There are presently three pressure machines available for this process, and all must be connected to a compressor for air pressure. They are the Druomat by Dreve (Unna, Germany, distributed by Raintree Essix, LLC, Metairie, La.,); the Erkopress by Erkodent, (Pfalzgrafenweiler, Germany, distributed by Glidewell Laboratories, Newport Beach, Calif.,) and the Biostar by Scheu Dental, (Iselkohn, Germany, distributed by Great Lakes Orthodontics, Ltd., Tonawanda, N.Y.). For the purposes of this paper, the Druomat will be used.

A 3 mm to 4 mm mouthguard will be made. Two layers of 3 mm ethylene vinyl acetate will be laminated together. It is important that this process be done in two separate steps to allow for proper thickness in the incisal and occlusal surfaces. If done in only one step, the thickness in these critical incisal and occlusal areas will be compromised. There is approximately 30 percent to 40
percent shrinkage of ethylene vinyl acetate material during fabrication, so
two 3 mm sheets laminated together
will form a 3 mm to 4 mm mouthguard.

**Figures 7a-b.** After the heater switch
and machine power is turned on, a 3
mm sheet of ethylene vinyl acetate is
placed in the disc positioning ring. The
trimmed model with marked extensions
is placed on the tray table slightly off
center toward the lingual.

**Figure 8a.** The clamping ring is
placed over the ethylene vinyl acetate
sheet to lock it into position.

**Figures 9a-b.** The heater is placed
into position over the model allowing
the ethylene vinyl acetate material to
heat and soften to formable consistency.

**Figure 10.** As the ethylene vinyl
acetate material softens, it will begin to
slump until it is touching the model. At
this stage, the first layer is ready to be
thermoformed by pressure.

**Figure 11.** On the upper left side of
the Drufomat is a white button that
activates the pressure. This button must
be pressed at the same time the heater is
removed from the ethylene vinyl acetate material. The pressure chamber
will drop over the model and thermo-
form and pressurize the ethylene vinyl
acetate to the model. A light will illumi-
nate signaling the thermoprocess has
begun and the hands can be removed
from the machine. If the hands are
removed prior to the light activation,
the pressure will not be maintained.

**Figure 12.** The ethylene vinyl
acetate material must now cool for a
minimum of 10 to 15 minutes. The eth-
ylene vinyl acetate material should not
be manipulated and removed from the
pressure chamber until it has completely
cooled to prevent any distortion.

**Figures 13a-b.** Once the time has elapsed, the white button is depressed
until the pressure indicator light shuts off
releasing the pressure in the chamber. The
heater lever is slowly pushed toward the
cylinder. The pressure cylinder will rise.

**Figure 14.** The first layer is com-
plete. It may be removed from the disc
positioning ring and allowed to cool to
room temperature before trimming to
prevent distortion.

**Figures 15a-c.** Once the ethylene
vinyl acetate material has cooled,
excess material may be trimmed off
using a hot knife. Care should be taken
not to trim excessively. The lingual bor-
ders are trimmed 1 mm from the teeth,
and the labial borders follow the pen-
ciled mucosal borders. The distal of the
first molar is the minimal extension.

**Figures 16a-d.** The first layer is now
ready for identification labels and
logos. Any label machine may be used
as long as it provides a small font (10
point maximum).
Figures 17a-c. The mouthguard is now ready for the second layer which will be laminated. A clear sheet of ethylene vinyl acetate of desired thickness (in this case, 3 mm) is placed in the disc positioning ring. The model with the first trimmed and labeled layer is placed on the positioning tray slightly off center toward the lingual. At this point, steps 8 through 13 (Figures 8a-13) are repeated. The clear second layer begins to melt to the desired formable consistency. It is very critical the second layer be allowed to become hot enough to predictably laminate to the first layer. It must heavily droop over the first layer. If not allowed to heat sufficiently, complete lamination will not occur and separation will take place in time. The pressure chamber is activated as in step 11 (Figure 11), and the model allowed to cool under pressure for 15 minutes. Steps 12-16 (Figures 12-16) are repeated.

Figure 18. The clamping ring is removed and the laminated mouthguard is allowed to cool to room temperature to eliminate any chance of distortion, thereby ensuring a perfect tight fit.

Figures 19a-b. The second layer excess ethylene vinyl acetate material is trimmed to proper extensions as in steps 15-16 (Figures 15-16).

Figure 20. The internal lingual extensions should be checked and marked with a pen to 1 mm from the teeth.

Figures 21a-b. With a Dedico stone acrylic bur, the excess material is trimmed lingually to the marked extensions. The mouthguard is then placed back on the model and the margins are feather finished for comfort lingually, buccally, and labially. Any interferences with muscle attachments should be removed. It is key to finish and thin the lingual extensions to provide comfort and ease in speaking. The lingual area should not remain bulky.

Figures 22a-c. With Essix Scotch wheels, the mouthguard is further trimmed and smoothed to desired thickness. All frenum attachments are relieved with a lisco disc.

Figure 23. Final finish and polish is
Figures 19a and b. Trimming the excess from the second layer.

Figure 20. Internal lingual extensions should be checked and marked.

Figure 19a.

Figure 19b.

Figure 18. With the clamping ring removed, the laminated mouthguard is cooled to room temperature.

Figures 21a and b. Final trimming with a Scotch wheel.

Figure 21a. Using a stone bar, excess is trimmed.

Figure 21b. Final trimming with a Scotch wheel.

Figure 22a and b. Final trimming with a Scotch wheel.

Figure 22a.

Figure 22b.

Figure 22c. Trimming frenum muscle attachments.

Figures 22a and b. Final trimming with a Scotch wheel.

Figure 23. Finish and polish is placed with wax remover.

Figures 24a-d. The 4 mm custom-made pressure laminated mouthguard is now completed.

Figures 25a-d. It is now important to try the mouthguard in the patient’s mouth and check for fit and comfort. Minimal adjusting may be necessary just as any other dental appliance insertion appointment. It is extremely important that a balanced occlusion be present. This is done by slightly warming the posterior occlusal surface of the mouthguard, taking extreme care not to overheat and distort, and placing the mouthguard in the patient’s mouth and asking them to bite down very lightly and carefully until all posterior teeth occlude. Care should be taken not to bite down excessively as the occlusal separation of 3 mm to 4 mm must be maintained to ensure proper absorption of impact energy.
Conclusion

The pressure-laminated mouthguard continues to be the mouthguard of choice and acceptance for athletes of all levels. The precise fit lends to an increased compliance and reduction of injuries. Athletes who have not been able to wear over-the-counter mouthguards in the past due to poor fit, bulkiness, and lack of retention are more prone to wear a mouthguard that is comfortable, non-bulky, and tight fitting.

References
4. Title IX of the Educational Amendments of 1972 is the landmark legislation that bans sex discrimination in schools, whether it be in academics or athletics. Title IX states: “No person in the U.S. shall, on the basis of sex be excluded from participation in, or denied the benefits of, or be subjected to discrimination under any educational program or activity receiving federal aid.”