

# CUSTOM-MADE FACE GUARDS FOR ATHLETES WITH OROFACIAL INJURIES

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## INTRODUCTION

Face guards are predominantly used by athletes playing sports with a high risk of orofacial injuries. Injuries may result from a variety of different mechanisms including direct physical contact with opponents or their protective equipment, being struck by opponents, balls, sticks or bats and also from contact with the boundaries of a playing arena surrounded by hard boarding. Examples of such sports are soccer, boxing, inline skating, skiing and Australian Rules football.

Ice hockey, American football and Irish hurling are associated with such a high risk of orofacial injury that players wear sport-specific helmets for training sessions and matches. These helmets are equipped with

sport-specific face guards. Some scientific studies have shown that wearing an adequate face guard or helmet significantly reduces the number of orofacial injuries<sup>1,2</sup>. In some cases however, the face guards can have a negative effect such as impairing vision. Sport-specific face guards and helmets are usually available in a variety of different sizes and are used in the primary prevention of injury.

Mouthguards are another common form of protection used by some sportsmen to protect against orofacial injury. These can either be custom-made or of the off-the-shelf ‘boil and bite’ type and are used in sports such as rugby, cricket, baseball, hockey, water polo and squash and sometimes tennis<sup>3</sup>.

Occasionally a custom-made face guard is used for the secondary prevention of injury following an orofacial injury. This is usually in a professional or high-amateur level athlete from a contact sport such as football who wishes to continue playing despite the injury. Examples of such injuries are surgically stabilised fractures of the mandible, zygoma or nose and less frequently the maxilla, the orbital wall or the frontal bone.

During the healing phase of a fracture, participating in contact training activities and playing matches is not recommended because of the risks of recurrent damage to the healing bone. Under these circumstances, a custom-made face guard that is safe and causes minimal discomfort

may allow a safe and earlier return to contact activities and competition.

#### FABRICATING AN INDIVIDUAL FACE GUARD

A detailed model of the entire frontal area of the head is required to make a custom-made face guard. Two methods are available:

1. Taking an individual impression which can be casted to make a plaster model or
2. using stereolithography to produce a plastic model.

#### Impression taking

The athlete should be half sitting and half lying (at about 60°) because in this position the skin and the underlying tissues are optimally relaxed and in a neutral position. The first step is the application of gauzes to the anatomical structures involved. Next a thin layer of alginate is put over the gauzes followed by another layer of gauzes on top of which a layer of plaster bandage is applied. This procedure makes it impossible to distort the alginate and it provides a solid plaster base to use for making the final impression (Figure 1).

It is recommended that the nostrils are filled with fatty gauzes to prevent impression material from entering the nose. This means the mouth has to be kept open to allow the athlete to breathe. However, it is important to instruct the sportsman beforehand to limit opening their mouth as much as possible to prevent deformation of the surrounding anatomy.

#### Stereolithography

Stereolithography is a 3D (anatomical) printing technology structure and has been developed in various medical disciplines<sup>4</sup> since the 1980s.

Using CT or MRI, cross-sections of the anatomical structure is built up layer by layer. Each layer has a thickness of about 1 mm and is saved as an image file format in a software programme. The standard format is Digital Imaging and Communications in Medicine (DICOM). Other applicable image file formats are JPEG, BMP and TIFF.

In a laboratory, the saved 2D images are transferred into a 3D model, using powdered, solid or liquid raw materials. An often-used material is fluid polyacrylate. Each cross-section is rendered by the fluid polyacrylate

and polymerized using a laser beam tuned at ultraviolet wavelength which cures and solidifies the pattern traced on the resin and joins it to the layer below (Figure 2).

#### Design and materials

In order to ensure proper design, each case should be individually assessed to ascertain which anatomical structures need protection and which hard anatomical structures may provide support and stability for the face guard. To provide maximal support and stability for the face guard, several hard anatomical structures need to be identified to distribute forces away from the vulnerable anatomical structures. For example, in case of a stabilised fracture of the zygoma complex, the frontal bone, the maxilla, the nose and the contra-lateral zygoma complex may serve as supporting anatomical structures (Figure 3) for the guard to direct forces away from the zygoma region.

Elastic strips can be threaded through holes in the face guard and then fastened with velcro fasteners around the back of the neck and head to fix the face guard in position (Figure 4).

The material of the face guard should provide maximal protection and safety for the athlete, but should also not cause any injury to the athlete or other competitors in the case of contact whether by direct trauma or from fracturing or splintering. Finding the right material is not easy but thermoplastic resins, for instance the so-called high-density polyvinyl chlorides, are suitable materials.

If the required moulding temperature of the material is relatively low then vacuum and/or pressure thermoforming machines are not required because hot water and finger pressure are sufficient to mould the material. However, resins with low moulding temperatures have relatively poor mechanical properties and therefore the face guard needs to be relatively thick, which can narrow the field of vision for the athlete. A solution for this problem is to reinforce a thin layer of the thermoplastic material with fibreglass<sup>5</sup>. The mechanical properties of resins need high moulding temperatures and therefore also need a vacuum and/or pressure thermoforming machine to mould the material, allowing for the manufacture of thinner masks.



**Figure 1:** Sportsman in half-sitting and half-lying position while the impression is being taken.

**Figure 2:** A three-dimensional stereolithography model of a face.

**Figure 3:** Area of the stabilised fractured zygoma complex, selected on the plaster model with a wide guide margin.



**Figure 4:** Final face guard with elastic strips to be fixed in the neck and at the back of the head using velcro-fasteners.



**Figure 5:** Reduced face guard after 4 weeks of wearing.

## DISCUSSION

An important task of the care providers when fabricating custom-made face guards is to support the athletes when they are familiarising themselves with the face guard during exercise. The professional soccer player, for whom the face guard of Figure 4 was fabricated, complained of severe perspiration between the guard and his face during exercise. Therefore, a second face guard was manufactured to enable him to wear alternately during exercise. The face guards were exchanged and cleaned and cooled in ice by one of the team coaches every 15 minutes during exercise until after 4 weeks the fracture of the zygoma complex had healed enough to allow a lighter face guard, much to the relief of the soccer player (Figure 5).

It is possible that wearing a helmet or face guard may make an athlete feel safer and allow more reckless play and as a consequence lead to an increased risk of injury. In the North American Ice Hockey League, the number of neck and back injuries has increased considerably since wearing a standard helmet with face guard became compulsory<sup>6</sup>.

Stereolithography is more expensive than impression-taking as CT or MRI is required but it is less labour-intensive and a more athlete-friendly method of fabricating an individual face guard. If a diagnostic CT or MRI scan of the head and neck region has already been done, this can be used for fabricating a custom-made face guard.

**A custom-made face guard may allow a safe and earlier return to contact activities and competition**

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