Temporal miniplates in the frontozygomatic area – an anatomical study

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ABSTRACT

Purpose The advantages of rigid fixation over wire osteosynthesis are well established for the management of facial trauma. Miniplates in the frontozygomatic area are traditionally applied to the lateral face of the orbital rim, but with some undesirable effects, such as palpability, visibility and risk of penetration into the anterior cranial fossa. The aim of this study was to perform an anatomical study to validate the use of miniplates on the temporal face of the frontozygomatic region.

Methods Osseous thickness measurements were performed in 30 skulls, on four points above and four below the suture, at 3 mm intervals, perpendicular to the bone surface.

Results There is enough bone thickness to apply the screws, ranging between 4 and 6.5 mm. The first hole over the frontozygomatic suture should receive the smallest screws and the other areas can receive screws up to 6 mm. All drillings are made from the temporal fossa to the orbit, and its contents should therefore be protected during the perforations. At the measured points there is no risk of anterior cranial fossa penetration.

Conclusion This study suggests that it is possible to use miniplates at the temporal aspect of the frontozygomatic suture.

KEYWORDS

Miniplates; rigid fixation; zygomatic bone; traumatology; maxillofacial surgery

INTRODUCTION

The zygomaticomaxillary complex is an essential element of the facial configuration. The zygoma is a diamond-shaped bone located in the middle third of the face, and has relations with the orbit, the maxilla and the temporal fossa. It has lateral, orbital and temporal faces [1]. The four articulations of the zygoma include the frontozygomatic suture (FZS), infraorbital rim, zygomaticomaxillary buttress, and zygomaticotemporal suture. Because of its location, it is subjected to trauma more often than any other element of the face except the nose. Although some injuries will involve an isolated orbital rim or antral wall fracture, most injuries will include the zygomatic bone, and thus the term “zygomaticomaxillary” [1]. The consequences of such injuries may involve ocular function, orbital shape, facial aesthetics, and mandibular mobility [2]. Trauma of the zygomatic complex constitutes a considerable percentage of all midface fractures and the best treatment time is generally considered to be as early as possible for fractures of the midface [3].

Fractures without displacement do not require surgery. But all fractures requiring surgery should also have some form of fixation [1]. This is particularly true in displaced, unstable cases with wide separation, displacement of the FZS, and rotation [4].

There are many methods to treat zygomatico-orbital fractures. Although simple methods such as elevation with a hook or the temporal approach are often associated with fewer complications, they are generally used in less complex cases. Wire fixation of zygomaticomaxillary fractures was used extensively in the past with satisfactory results, although some rotation or displacement of the fractured ends could not always be avoided, and the inclusion of small but occasionally important fragments could not always be achieved [1].

In the 1970s, introduction of miniplate osteosynthesis for treatment of zygomatic complex fractures revolutionized the treatment [5]. Stability and exactness of the reduction are still debated with regard to the number of plates applied to the facial buttresses (latero- and infraorbital rim, zygomaticomaxillary crest) [6]. Anatomical studies of the zygoma have shown that the FZS has enough bone for miniplate fixation. A sound anatomic knowledge of bony dimensions of this area is very important to avoid the risk of penetrating the orbit and the cranial cavity when drilling [7]. It is also important to know the osseous thicknesses of the region to determine which screw should be used for the plate [8]. On the points above the FZS, there is always a risk of penetrating the orbit, because of the presence of the lachrymal gland fossa, or the anterior cranial fossa. Five millimeters screws have been suggested above the suture, and 7 mm screws below [7, 9]. Although miniplates have been routinely applied to the lateral face of the zygoma, there have been reports of palpability of the plates in this area, suggesting the use of smaller plates [10].

Palpability and visibility of the plates may occur mainly in areas where the skin is thinner, as in the FZS region. With this in mind, the aim of this study was to perform an anatomical study of the FZS region to validate the use of miniplates on its temporal face, evaluating the risks of orbit and cranial fossa penetration, as well as determining the possible screw sizes to be used.

MATERIAL AND METHODS

Thirty skulls were used in this study, obtained from the Department of Morphology (Federal University of Minas Gerais, Brazil). The skulls were well preserved, with no eroded parts, and all measurements were performed on the right side.

The measurement points were defined based on the possible uses of 1.5 mm four hole mini plates with or without intermediate segment. The plates were adapted to the temporal face of the FZ suture, and the drilling points marked (Figures 1 and 2). When applying the plate with an intermediate segment, the measurement points were named A, C, F and H, and for the plate without the segment, the measurement points were B, D, E and G (Figures 1 and 2).

Therefore a total of 4 measurements above and 4 below the suture were made with a 3 mm distance between each point. The thickness measurements were made with a stainless steel metric dial caliper with 0.1 mm precision, perpendicularly to the bone surface. All thickness measurements were also made perpendicular to the external bone surface, just as in drilling. The possibility of entering the orbit or the cranial fossa was also evaluated.

Basic descriptive statistics was employed to analyze the data obtained using standard software (Excel©). The following study was approved by the ethics review committee of the university.

RESULTS

The results show that there is enough bone thickness to apply screws on the temporal face of the FZ region. The mean average bone thickness varied between 4.07 mm (point D) and 6.64 mm (point A) (Figure 3).

The lowest measurement was obtained in the area located immediately above the FZS, and the thickness increases gradually when moving upward. Below the suture, the thickness is more constant, although it increases slowly when moving downwards (Figure 3).

The data obtained with the depth measurements on points B, D, E, and G used for 1.5 mm miniplates without intermediate segment were statistically analyzed and are shown in Table 1. The first hole over the FZS (point D) showed the smallest mean thickness (4.07 ± 1.49), and the points more distant from the FZ showed the largest mean thickness.

The data obtained with the depth measurements on points A, C, F, and H used for 1.5 mm miniplates with intermediate segment are shown in Table 2. The first hole over the FZS (point C) showed the smallest mean thickness (4.56 ± 1.58), and the points more distant from the FZ showed the largest mean thickness.

Figures 5A and 5B illustrate a surgical case.

DISCUSSION

The treatment modality in zygomatic complex fractures is still controversial. Some authors still favour percutaneous hook reduction in cases of fresh fractures [11] or consider it in cases of less complex fractures [12], although it is admitted that rigid internal fixation offers better results and the traditional methods have a high rate of malunion [12]. Other authors expose the infraorbital rim routinely and perform multiple osteosynthesis [6] or even expose all or nearly all fracture lines [3]. Gruss et al. [13] see an indication for routine coronal incision even in cases confined to the orbitozygomaticomaxillary region, to restore the zygomatic arch using miniplates and screws. Reasons for a minimizing treatment include the avoidance of multiple surgical approaches, consequent potential infections, additional scars and nerve palsy.

In the late 1980s microsystems for internal fixation of maxillofacial fractures were introduced because of a growing demand for smaller systems [14]. The microplates have the advantage that they can anatomically fix small bone pieces [14]. The soft tissue overlying the orbital rim is very thin, thus necessitating a thin plate to prevent visibility, sensibility and palpability. The muscular forces acting on the zygomatic complex are much weaker than those exerted on the mandible. Therefore, the thinner, more adaptable, microplates may be used [15]. But Luhr [14] itself had said that this microsystem was not recommended for osteosynthesis at the FZS because of lack of rigidity.

Implantation of biodegradable screws and plates in load-bearing areas such as the zygomaticomaxillary buttress, the infraorbital rim and the FZS seems to be a significant biomechanical challenge to implant stability. Biodegradation is dependent on soft tissue coverage, which may be extremely thin in the periorbital region [16]. Despite the many theoretical benefits that biologic systems may have, the size of the devices, their adaptability, and other clinical handling properties have been found to be inferior to titanium fixation systems [17].

Miniplates offer better stabilization at the fracture site, can be easily adapted, and are placed passively, allowing normal tension and flexion. In selected cases, they may even be placed under local anesthesia, thus reducing the hospitalization time and expense. Miniplates do not allow compression but are rigid due to the increased surface area between the screws and the bone, the increased three-dimensional stability, and the rigidity of the plate itself [18]. The introduction of titanium has contributed to the malleability and biocompatibility of the hardware.

Although it is suggested that most zygomatico-orbital fractures can be treated adequately by simple elevation, this is vigorously disputed [19], and some surgeons feel that a single site of fixation is less than ideal [3]. The multiple-site approach is based on the principle of distracting forces generated by the muscles of mastication, particularly the masseter muscle, acting around an axis between the FZS and the lateral buttress. The masseter muscle, however, develops significantly less force in function in patients with zygomatic complex fractures than controls [20], and it is possible that its role has been overemphasized by those proposing extensive osteosynthesis. It is also worthwhile bearing in mind that the frontozygomatic process is part of the buttress system transmitting vertical compressive force from the maxilla, and that this will oppose masseteric distracting forces.

It could be demonstrated that a symmetric reconstruction of the malar prominence could be achieved by the FZS fixation [21]. The result remained stable until ultimate bony consolidation, corresponding to experimental findings in human skulls comparing different methods of internal fixation [22] where one miniplate at the FZS line was the minimum requirement for stable fixation. The infra orbital rim is very thin and is usually

the least important site for semi-rigid fixation of the zygomatic complex. And routine exposure and reduction of the infraorbital rim and the orbital floor bear the risk of additional trauma to the infraorbital nerve, even if great care is taken. Additional plates at the infraorbital rim or in the region of the zygomaticomaxillary crest are indicated only in cases where the zygomatic bone cannot be reduced by hook reduction and single location fixation. This is by definition necessary only in cases of comminuted fractures [21]. For these reasons, the FZS was the region of our study.

But problems such as extrusion, migration, sensibility (particularly in cold weather) and palpability can arise from the use of miniplates in the FZS region because of the thin overlying skin [23], often leading to a second surgery to remove the miniplates and the screws [24]. The temporal placement suggested here avoids such complications since the miniplates are neither palpable nor visible on this position (Figure 4) and would only be removed in case of infection.

When using miniplates without an intermediate segment, the first hole over the FZ suture (point D) should receive the smallest screws and the other areas can receive screws up to 6 mm (Table 1). When using miniplates with an intermediate segment the thinnest area is still immediately above the suture (point C), a result that indicates the use of 5 mm screws. The other areas can receive screws between 6 and 7 mm (Table 2). Therefore, the use of miniplates with an intermediate segment seems to be more appropriate since it avoids drilling at the thinnest area (point D).

All measurements showed that the drilling direction is towards the orbit; therefore its contents should be protected during the perforations with an instrument, and depth marks on the drill should be used. At the measured points we did not observe risk of anterior cranial fossa penetration, i.e., there is no risk of anterior cranial fossa penetration when the miniplates are applied to the temporal aspect of the FZ suture. This fact was also observed by Reher and Duarte [9] when internal fixation with miniplates was utilized at the region of the FZS, but at orbital lateral rim. They noted that the lowest point of the anterior cranial fossa that could be reached while drilling perpendicularly to the bone surface was at a mean distance of 17.01 mm ($SD \pm 3.49$) superior to the FZS. At this point, they observed a mean diploë thickness of 9.18 mm ($SD \pm 2.51$). In 92.06% of the cases (subtracting the standard deviation from the mean value), the measure of 13.5 mm could be used as a reference mark. When one drills above this level, the risk of reaching the cranial cavity using screws bigger than 7.0 mm increases. Considering this, we should not use miniplates with a greater length than 27 mm, because in a miniplate with this maximum length, half of its length (13.5 mm) will be located below the FZS and the other half above, in order to place two screws in each half.

The temporal surface of the FZ area on the 30 skulls used in this study was smooth and their shape allowed easy mini plate contouring and adaptation. As shown in tables 1 and 2, the bone thickness in this area is enough to allow screw insertion, of 5 to 6 mm screws. However, care should be taken in elderly patients with thinner bone, since some skulls had a thin bone (the lowest of all measurements was only 1 mm in point D). In these cases plates with an intermediate segment would be indicated, and the smallest screws should usually be applied on the first upper hole (point E).

Supraorbital, eyebrow and coronal approaches are usually employed to reach this area, and for the suggested temporal plate placement, the last two seem to be more appropriate, though the coronal approach should be used only in suitable need, i.e., when treatment of associated fractures in the upper third face is

advisable. The temporalis fascia should be detached from the area and the temporalis muscle retracted posteriorly, exposing the temporal face of the FZ area.

Special care should also be taken with regard to drill access and angulation. Drill angulation is forward toward the orbit, and the skin over the temporal fossa as well as the orbit content should be carefully protected.

CONCLUSIONS

This study suggests that as far as the bone structure is concerned, it is possible to use miniplates at the temporal aspect of the FZ suture. The first hole over the FZ suture should receive the smallest screws and the other areas can receive screws up to 6 mm. All drillings are made from the temporal fossa to the orbit, and its contents should be protected during the perforations. This new position of the mini plates reduces the risk of perforating the anterior cranial fossa, avoids skin palpation of the miniplates, and can be applied using standard approaches, making it an useful option when miniplate fixation in the FZ area is indicated.

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FIGURE LEGENDS

Figure 1. Measurement points in the temporal face of the FZ suture. Points A, C, F and H, were obtained using a miniplate with an intermediate segment; points B, D, E and G using a miniplate without the intermediate segment.

Figure 2. Placement of miniplates on the FZ suture. (A) Miniplate without an intermediate segment (points B, D, E and G). (B) Miniplate with an intermediate segment (points A, C, F and H).

Figure 3. Mean thicknesses on the selected measurement points (error bars show $\pm$ SD).

Figure 4. Temporal placement of the miniplates. (A) Lateral view. The bottom screws require more angulation of the screw driver and hand piece toward the temporal fossa. (B) Frontal view. The plates are not palpable at the orbital rims.

Figure 5. An illustration of a surgical case.

TABLES

Table 1 – Osseous thicknesses of points used for 1.5 mm miniplates *without* intermediate segment (n= 30)

	Mean $\pm$ SD	Range	Mean – SD
Point B	5.69 $\pm$ 1.97	2.1-9.0	3.71
Point D	4.07 $\pm$ 1.49	1.0-6.8	2.57
Point E	5.21 $\pm$ 1.71	2.2-8.0	3.49
Point G	5.88 $\pm$ 1.50	1.9-8.0	4.37

Table 2 – Osseous thicknesses of points used for 1.5 mm miniplates *with* intermediate segment (n= 30)

	Mean $\pm$ SD	Range	Mean - SD
Point A	6.64 $\pm$ 2.19	1.5-10.0	4.45
Point C	4.56 $\pm$ 1.58	1.5-7.4	2.97
Point F	5.49 $\pm$ 1.48	2.5-7.7	4.00
Point H	6.06 $\pm$ 1.70	1.8-8.6	4.36

Bone Thickness at the Determined Points