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Radiographic and Clinical Evaluations of the Zygomatico-maxillary Complex Fractures Treated by 2.0 Miniplates System

Evaluaciones Radiográficas y Clínicas de Fracturas del Complejo Cigomáticomaxilar Tratadas por el Sistema de Mini Placas 2.0

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ABSTRACT: The zygomaticomaxillary complex (ZMC) is the second highly incidental of facial fractures. According to the anatomical complexity, there are many reports in the literature about this trauma, mainly related to treatment for these fractures. With the purpose of evaluating clinically and radiographically the stability of unilateral zygomatic fractures treated by surgical reduction and fixed in two points by stable internal fixation, this research was proposed. Twenty patients with zygomatic fractures were evaluated and compared with twenty nonfractured patients. The results showed that there were no statistically significant differences among the obtained data, perimeter and area, of the treated and contra-lateral sides of the experimental group. When compared to the control group the differences were not statistically significant. We also performed a comparison of the distance between the nasal bone and zygomatic prominence in all groups the results were also satisfactory.

KEY WORDS: zygomaticomaxillary fractures, stable fixation internal, facial injuries.

INTRODUCTION

The zygomaticomaxillary complex (ZMC) is an essential element in face configuration and due to its location and prominence is the subject of greatest trauma incidence, with exception of the nasal bones (Zachariades *et al*., 1998). Among the most common causes of this type of injury are motorcycle accidents, physical aggressions, and car accidents (Ellis *et al*., 1985).

Several treatment methods for ZMC fractures are mentioned (Larsen & Thomsen, 1985; O'Sullivan *et al*., 1998) all of them with the same aim: bone repositioning, and functioning of the patient and esthetics (Marciani & Gonty, 1993). The literature on ZMC fracture treatments is conflicting regarding the need of fractures fixation after their surgical reduction. Zingg *et al*. (1992) report that the determinant factor to define the best treatment will be trans-surgical, when it is possible to verify the degree of instability of the fracture. With the advent of the rigid internal fixation warranting options for better fracture management (Fonseca & Walker, 1997), several researches were conducted relating the degree of instability with the amount of fixed points (O'Sullivan *et al*.).

Many authors inform that safe stability is reached through a three-point fracture fixation, due to muscle action over the ZMC (Bacelli *et al*.). Zingg *et al*. (1992) report that a fixation in two points is enough for ZMC fractures stabilization. Nevertheless, Fain *et al*. (1981) obtained success in the conduction of fixation in only one point of the frontozygomatic suture, because this is the area where the tension forces act directly.

Therefore, because of the great incidence of this type of fracture and due to the great controversy related

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to their treatment in the literature, we conducted the present study, evaluating the postsurgical results of patients with ZMC unilateral fractures, treated through surgical reduction and stable internal fixation with 2.0 mm system plates and screws on two points.

MATERIAL AND METHOD

For the present study, we have evaluated twenty patients of the Oral and Maxillofacial Surgery Department of the Araçatuba Dental School – University of State of São Paulo submitted to surgical treatment of unilateral non-comminuted fracture of the zygomaticomaxillary complex (TG) and twenty control patients (CG) without facial fractures, and with matching sex and age between the groups.

The follow up for the treated patients were greater than six months. A clinical and radiographic evaluation of the fractured patients was conducted comparing the operated side (OpS) with the contralateral side (ClS). On the patients without facial fractures the analysis was radiographic.

The surgeries were conducted under general anesthesia, following the surgical sequence described by Fonseca & Walker. The frontozygomatic region was incised always in the supraciliary region, preserving the eyebrow. The second region to be evaluated varied according to surgical need for each case, always fixing it on the infraorbital region or the maxillozygomatic buttress.

The surgical reduction was reached through use of Caroll-Girard screw, as suggested by Kreutziger & Kreutziger (1992). The stable internal fixation was made in all patients by means of 2.0 mm system titanium miniplates and screws with a minimum of two screws on each side of the fracture in the mentioned regions: the frontozygomatic suture and the infraorbital ridge or zygomatic buttress. All patients received antibiotics, steroidal and non-steroidal anti-inflammatory and mouthwash as pre and postsurgical medications.

Radiographic Evaluation. The orbital cavities were evaluated through antero-posterior Waters radiographic views to verify the adequate fracture reductions. A 15mA, 80kVp electric regime, with two-second exposure and ecran Kodak Lanex regular Screens were used. The radiographies obtained (20 operated patients and 20 control patients) were scanned with a "ScanJet 4c/T" scanner and Pentill program, with 916K resolution and 50% scale, 126 of contrast and 126 of luminosity. All radiographies had their image size pre-established to avoid differences between them.

The images were analyzed with ImageLab 2000 – a software of image analysis and processing, version 2.4. For orbital cavity border enhancement, the images were changed, with the feature "Border Enhancement" and "Pseudocolorization", thus facilitating the observation of structures of the interest area on the radiography (Fig. 1A and B).

The orbital cavity outline was obtained through manual delimitation of its perimeter (Fig. 1C); then, using the feature "Region Calculation", the perimeter and orbital cavities area values were obtained. Measurements were also taken of the distances between the point located next to the frontonasal suture and the median suture of the nasal bones to the most lateral point located next to the zygomatic arch using the same software, with the command "Straight Line Calculation" (Fig. 1D).

Thus, the operated side (OpS) was compared with the contralateral side (ClS) of the Treated Group (TG). The same procedure was carried out with the Control Group (CG) patients, comparing both sides (right side – RS and left side – LS), obtaining comparison values.

Clinical and Radiographic Evaluation of the Operated Patients. Considering the possible sequelae, anatomical loss and possible fractured bones dislocations resulting from the surgical approach, facial symmetry and clinical signs and symptoms such as ocular movements, diplopia, visual acuity, paresthesia, mouth opening limitation, dystopia, ectropion, entropion, apparent sclera, enophthalmia, exophthalmia were analyzed.

On the TG, the patients varied from 21 to 54 years of age, with an average of 35.10 years, with predominance of males (90%) compared to females (10%). The left side was more affected, in a ratio of 11:9 compared to the right side. The follow up ranged from 6 months to a maximum of 72 months, with an average of 22 months.

Among the etiologic factors of the ZMC fractures, a prevalence of motorcycle accidents were verified (45%), followed by physical aggressions (25%). Car accidents and sport accidents had the same incidence,

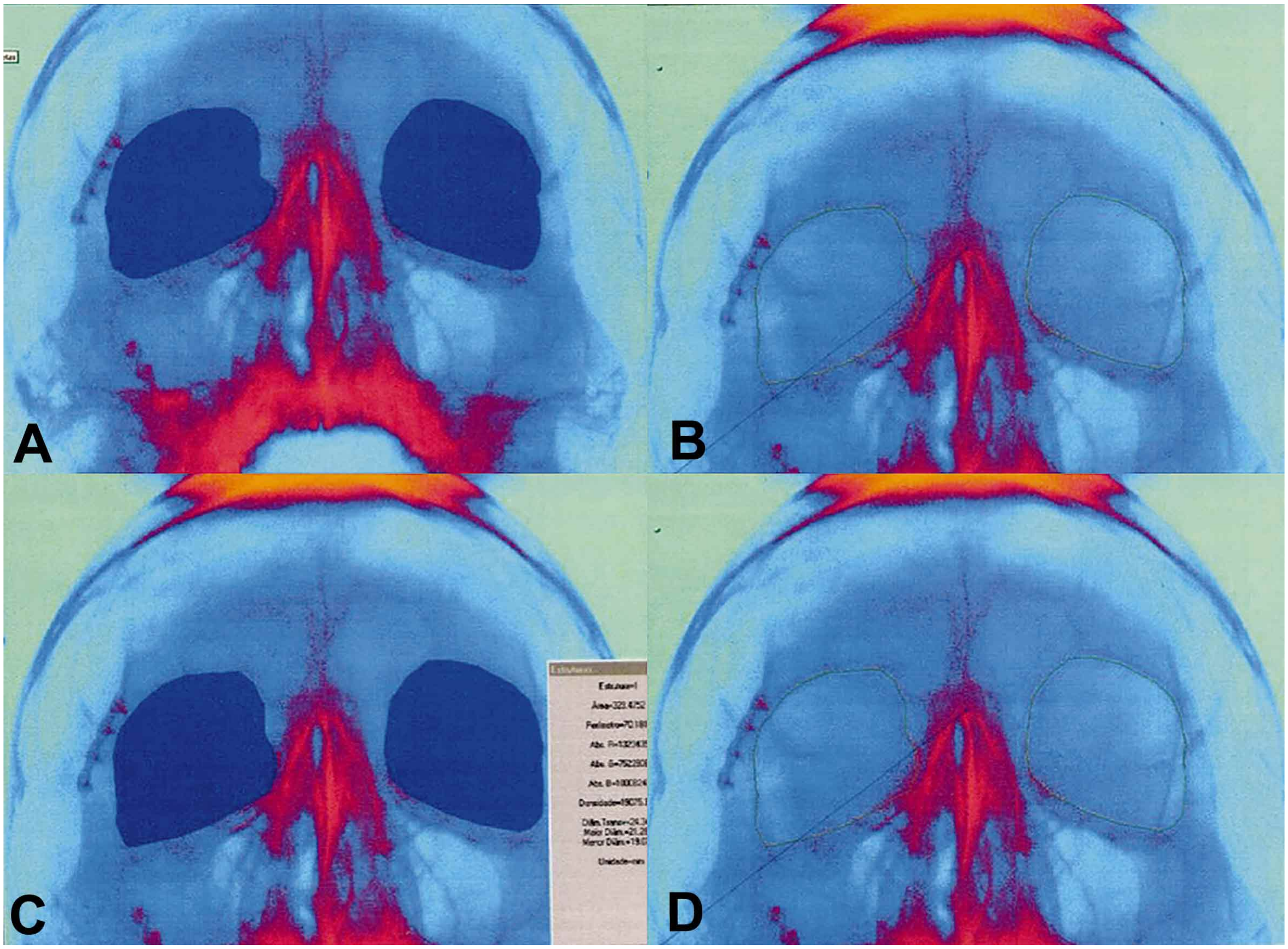

Fig. 1. A–D. Standard scanning posteroanterior X-rays on the program ImageLab 2000/2.4 Enhancing the osseous outlines in order to facilitate the demarcations of the NP, ZP and to calculate the perimeter and area of the orbits. The distance from the NP to the ZP.

10% each. Bicycle falls and run over happened to one patient in each group, totaling 5%. The data obtained were analyzed statistically, using the parametric T-Student test.

For stable internal fixation of the fractures of the TG, in 100% of the cases, the first fixation point was done in the frontozygomatic suture. In 60% of the cases, the second fixation point chosen was the infraorbital ridge and 40% on the maxillozygomatic buttress.

Through evaluation of the postero-anterior Waters radiographies we can verify the measurement of the perimeter as well as the orbital cavities area both of the TG and the CG. For statistical test of the data, the T-Student test, a parametric analysis, was used. Analyzing the statistical differences of the perimeter values of the orbital cavities on the operated side (OpS) and on the contralateral side (ClS), we concluded that they are not statistically significant for $p<0.05$, and the probability of equality (null hypothesis) was 93.38% (Table I).

As to the difference of orbital cavities area of the operated side (OpS) and of the contralateral side (ClS), again the results were not statistically significant for $p>0.05$, with a probability of equality (null hypothesis) of 93.72%. The Control Group analysis followed the same protocol adopted for the Treated Group. The values obtained for the perimeter and analysis area of the orbital cavities of the left side (LS) and of the right side (RS) are shown on Table II. A statistical analysis of the difference found related to the perimeter of the orbital cavity of the right side (RS) and of the left side (LS), were statistically non significant for $p>0.05$, and the probability of equality (null hypothesis) among the groups was 94.94%. In relation

Table I. Measurements, in millimeters, of the orbital cavities perimeter and area of the operated side (OpS) and of the contralateral side (ClS), in postero-anterior Waters incidence, of the patients studied and submitted to surgical reduction.

Patient	Perim.	Area	Perim.	Area
1	48.2	159.7	53.4	188.1
2	64.9	274.5	64.9	281.5
3	65.3	273.7	60.9	241.1
4	67.2	291.3	67.1	290.0
5	62.4	246.7	62.4	255.8
6	61.7	251.8	63.5	272.3
7	64.6	285.2	68.1	312.7
8	62.8	258.9	60.0	242.4
9	58.6	223.4	58.1	218.2
10	54.8	193.9	57.9	206.8
11	65.5	281.1	61.1	246.7
12	66.3	309.9	65.6	295.8
13	65.8	292.7	64.2	277.1
14	60.3	246.4	61.1	262.1
15	63.2	265.0	63.2	267.0
16	63.4	265.6	62.5	256.6
17	59.8	234.7	59.1	227.2
18	62.8	259.7	64.1	274.9
19	57.5	218.3	57.5	220.3
20	60.17	237.31	59.9	242.02
Average	61.86	255.16	61.84	255.02

Table II. Measurements of the orbital cavity on the right side (RS) and the left side (LS) on the Waters postero-anterior incidence, of the patients studied who have not undergone zygomaticomaxillary complex fracture, belonging to the Control Group (CG), from March 1997 to December 1999.

Patient	Perim.	Area	Perim.	Area
1	56.3	219.5	60.6	217.4
2	63.8	263.4	62.5	261.1
3	64.2	287.5	64.3	285.4
4	62.3	267.5	62.4	266.4
5	59.7	221.9	59.1	220.9
6	55.8	227.0	54.5	224.2
7	66.5	297.7	66.8	304.4
8	64.2	280.4	65.9	281.3
9	61.7	252.2	61.5	251.7
10	69.8	321.5	68.5	322.5
11	61.6	258.1	60.9	258.7
12	64.8	288.0	64.5	288.4
13	58.5	237.5	57.6	252.5
14	61.7	256.5	61.5	257.9
15	63.9	271.1	63.8	272.9
16	62.5	253.2	61.2	254.2
17	62.9	269.7	63.3	270.4
18	60.7	236.0	61.2	237.6
19	66.8	293.3	68.2	296.6
20	56.4	199.7	54.0	197.6
Average	62.23	260.68	62.23	260.95

to the orbital cavity area, the differences found between the RS and the LS, for $p>0.05$ again were not statistically significant and the probability of equality (null hypothesis) between the groups was 92.70%.

By means of a postero-anterior Waters radiography we have also carried out measurements of the nasal bone distance (NP) to the zygomatic prominence (ZP), both of the Treated Group and the Control Group. The statistical analysis of the difference of the OpS and the ClS distance for the Treated Group was statistically significant for $p>0.05$ and the probability of equality (null hypothesis) was 91.98% (Table III). This OpS distance average was 42.19 mm and the ClS distance was 42.22 mm.

Table III. Measurements of nasal bone distance to the zygomatic prominence of the operated side and the control side on the postero-anterior Waters incidence, from the patients studied and submitted to surgical reduction with rigid internal fixation of unilateral fractures of the zygomaticomaxillary complex.

Patient	Distance	Distance
1	40.68	40.42
2	43.31	43.57
3	41.10	41.15
4	44.22	44.28
5	42.42	42.19
6	42.23	43.83
7	43.43	42.36
8	45.58	45.12
9	44.00	44.56
10	46.52	47.66
11	44.17	44.24
12	40.63	40.27
13	42.50	45.50
14	43.77	43.96
15	45.43	45.72
16	45.10	43.06
17	44.04	44.05
18	42.08	42.93
19	40.86	41.42
20	42.84	41.93
Average	42.19	42.22

The same measurement procedure of the distance from the nasal point to the zygomatic point of the RS and LS of the Control Group patients was conducted. The data obtained are found on Table IV and the differences were not statistically significant for $p<0.05$, and the probability of equality (null hypothesis) was 90.52%. The distance averages from the RS were 42.19 mm and from the LS were 42.24 mm.

As to clinical evaluation, no case of ectropion, entropion, exophthalmus or enophthalmus were found among the patients of the Treated Group. One case of dystopia was found, classified as very discreet, corresponding to 5% of the treated patients. No case of diplopia, apparent sclera, or infection was found.

There were four reports of paresthesia persistence, corresponding to 20% of the Treated Group (TG) cases. Facial asymmetry was also verified in one patient of the Treated Group (TG), corresponding to 5% of the cases. In one case the patient have reported that the operated side was different from the contralateral one, however this difference was not uncomfortable.

Table IV. Measurements from the nasal point distance (NP) to the zygomatic point (ZP) of the left side (LS) and the right side (RS), on the Waters postero-anterior incidence of the Control Group (CG) patients without zygomaticomaxillary complex fracture, from March 1997 to December 1999.

Patient	Distance D	Distance AND
1	39.66	40.05
2	40.84	40.74
3	42.53	42.85
4	41.21	41.52
5	46.44	46.97
6	40.82	40.00
7	46.15	46.27
8	41.79	41.89
9	42.30	42.03
10	41.57	42.07
11	38.82	38.91
12	41.33	41.94
13	35.11	34.74
14	43.05	43.12
15	44.71	45.12
16	42.51	42.30
17	42.81	42.19
18	41.85	41.49
19	44.72	45.53
20	45.49	45.08
Average	42.19	42.24

DISCUSSION

Compared to other traumas, the facial traumas show higher incidences (Haidar, 1978; Ugboko *et al*., 2005; Haug *et al*., 1990). Periodical epidemiological reviews are valuable to reconfirm the previously established tendencies or to identify new factors conducting to fractures (Ugboko *et al*.). Since Durveney (1751) first report on treatment of the zygoma fracture, several treatment methods have been suggested. Among these treatments from nonintervention, also called conservative treatment, to fracture observation through open reduction and internal fixation (Fonseca & Walker). In all the suggested methods, the aim is to adequately return the loss of anatomical format, restoring the habitual function, preventing the late visual disorders and cosmetic deformities (Fain *et al*.).

The decision on intervention will be based on present signs and symptoms and on function changes. Once the need for surgical treatment is established, it includes the same principles of any face-fracture treatment, that is: reduction, fixation and immobilization (Sands *et al*.).

There are reports suggesting the need of aggressive surgical procedures such as ZMC fracture fixation through open reduction with 3 to 4 points exposure (Fonseca & Walker; Karlan & Cassisi, 1979) and others discussing the need or not of fracture fixation (Karlan & Cassisi; Dal Santo *et al*., 1992).

However, Fain *et al*. and Manson *et al*. (1987) report that fixation is essential to prevent rotation of the zygomatic bone, and the stability can be achieved both with plates and screws, in one or two points, with no need for conducting it in three or four points, other than cases of comminuted fractures.

The ZMC fracture instabilities are directly due to the masseter muscles action, and indirectly, by the medial pterygoid and temporal muscles besides fiber association of the facial expression muscles (Rinehart *et al*., 1995), although there was no rotation of the zygomatic bone when simulating action of masseter muscle forces in ZMC fractures fixed in two points: frontozygomatic suture and infraorbital ridge. Ellis & Kittidumkerng (1996) evaluated clinically and radiographically 22 patients 6 months after ZMC fractures surgeries and showed that the existence of ill-positioned zygomatic bone, probably demonstrate only that these fractures were not adequately reduced. So, we believe that postsurgery dislocations of the zygomatic bone, frequently related to masseter muscle action, can now be related to an inadequate reduction. This care is justified not only because of the masseter and facial mimic muscles action in ZMC, but also due to the resistance of the ZMC rigidly fixed being lesser than the resistance of ZMC on the non fractured side, on the first three postsurgical months (Garza *et al*., 1993).

The data obtained in our study concur with the results obtained by Ellis *et al*., Rohrich & Watumull (1995) and Ellis & Kittidumkerng. The differences obtained, both for the perimeter and area of the operated side (OpS) and the contralateral (ClS) side of the TG were not statistically significant for p>0.05. The good stability obtained with a two-point fixation became reinforced when compared to the data from the CG, that is, the patients without ZMC fractures. Based on these, it was verified that the differences of the values obtained between the right side (RS) and the left side (LS), both on the perimeter and the orbital area were not statistically significant (p>0.05).

When we compared the average values of the perimeter (61.85 mm) and of the area (255.1 mm2) of the TG, and the average values of the perimeter (62.16 mm) and of the area (260.81 mm2) of the CG, we were able to note that the results of the two groups were very similar.

The measurement of the nasal bone point (NP) distance to the zygomatic prominence point (ZP) was also a variable assessed in this study. In the TG, the value average was 42.205 mm, and the probability of equality (null hypothesis) was 91.98% between the sides. In the CG, the valuesobtained were very close to the TG ones, being its average 42.200 mm and the probability of equality (null hypothesis) 90.52%, and meaning that the fixation in two points is stable.

The ZMC treatment clearly involves a series of clinical details to be considered. The ZMC reposition in the three dimensions next to the zygomatic arch reposition and ocular changes should be considered on the treatment scheme. An inadequate conduct may result in esthetical and functional deformity. An incorrect primary reconstruction became the basic etiology of posttraumatic deformities, such as enophthalmus, telecanthus, loss of zygomatic prominence (Hammer & Prein, 1995).

As for the clinical evaluation, it was possible to observe that the facial asymmetry on the TG patients evaluated occurred in 5%. According to literature reports the facial asymmetry may occur in 20 to 40% of the cases in rigid internal fixations (Perino *et al*., 1984). Usually it is related to the time taken to conduct the surgical reduction, and also to the failure in obtaining a surgical access for an adequate exploration of the fracture sites.

When asked about any discomfort, nine of the 20 patients of the TG reported discomfort due to the presence of the plates (45%). Among these patients, six had plates in the infraorbital ridge region (55.5%). According to Haug (1996), the titanium plates can stay as permanent grafts on the face; from the nine patients reporting discomfort due to the presence of the plates, six decided for its removal, even without any sign of infection. This denotes that, perhaps, the best treatment for patients who suffered ZMC fractures is the placement of the more delicate 1.5 mm or 1.0 mm systems plates, which being more delicate will decrease the patients' discomfort.

CONCLUSION

Based on radiographic and clinical findings the surgical reduction and the stable internal fixation in two points were the adequate treatment for the cases of non-comminuted fractures of the ZMC.

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RESUMEN: Las fracturas del complejo cigomaticomaxilar son las segundas más frecuente del territorio facial. De acuerdo con la complejidad anatómica, existen muchos informes en la literatura sobre este trauma, principalmente relacionadas con el tratamiento de estas fracturas. El propósito de esta investigación fue evaluar clínica y radiográficamente la estabilidad de las fracturas cigomáticas unilaterales tratadas por reducción quirúrgica y fijadas en dos puntos por fijación interna estable. Veinte pacientes con fracturas cigomáticas fueron evaluados y comparados con veinte pacientes sin fracturas. En el grupo experimental, los resultados mostraron que no hubo diferencias estadísticamente significativas entre los datos obtenidos del perímetro y el área de los lados tratados y contralaterales. Al comparar estos datos con el grupo de control las diferencias no fueron estadísticamente significativas. También se realizó una comparación de la distancia entre el hueso nasal y la prominencia cigomática en todos los grupos, estos resultados también fueron satisfactorios.

PALABRAS CLAVE: fractura cigomático maxilar, fijación interna estable, lesiones faciales.

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