Surgical sequence of reduction in double mandibular fractures treatment

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AIM: *This study aims to clarify, according to our experience, the correct surgical sequence which should be followed in order to treat double mandibular fractures.*
MATERIAL OF STUDY: *From January 2007 to January 2010, we have conducted a retrospective study on a sample of patients operated on in our department. We include only those cases in which the jaw was fractured in 2 places, in particular patients who suffer a fracture in tooth-bearing areas (symphysis, parasymphysis, and anterior body) and also contralaterally in non tooth-bearing areas (posterior body, angle, ramus, and condyle). The sample was divided into 2 groups based on the fracture sequence of reduction.*
RESULTS: *At 1-year follow-up, the group of patients who received first the tooth-bearing fractured areas treatment, followed by treatment of non tooth-bearing fractured area on bifocal mandibular fracture (Group A), showed less postoperative complications and reduced surgical time and costs.*
DISCUSSION: *In patients of group B, the non-execution of rigid IMF for the non tooth-bearing fractures made bone segments more free to move. Thus, reduction and fixation of non tooth-bearing fractures is facilitated, but poses a greater risk of complications. The surgeon in this case does not have the occlusal help guide; thus, the tooth-bearing fracture reduction and the subsequent fixation may be imperfect.*
CONCLUSION: *It is recommended from this study that reduction of the tooth-bearing fragment be prior to that of the tooth-free fragment for the double mandibular fracture.*

KEY WORDS: Double mandibular fractures, Toothbearing area, Multiple mandibular fracture, Non-toothbearing area

Introduction

Fractures of the mandible have been reported to be between 40% and 62% of all facial fractures. More than 50% of mandibular fractures are multiple and among these the most frequent fractures are double [1-3].

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High frequency of double fractures in the jaw can be explained by the shape of this bone.
From a biomechanical point of view the jaw behaves like an arc whose ends are constituted by the condyles which are free to rotate inside the glenoid fossa [4].
In response to the load, forces are not distributed in uniform way as in a smooth curve due to the inhomogeneous bone density and frequent irregularities of the mandibular body.
According to this principle the jaw can be divided into tooth-bearing areas (symphysis, parasymphysis, and anterior body) and non-tooth-bearing area (posterior body, angle, ramus, and condyle). The kinetic energy of a direct trauma in tooth-bearing regions will be transmit-

ted along the mandibular arch concentrating in non-toothbearing areas.
In this case there will be a direct fracture under the impact zone and contralaterally an indirect fracture in an area of lesser resistance.
When multiple fractures of the mandible are considered, the most common combinations are angle and opposite anterior body and subcondylar and opposite anterior body [5].
In the management of any bone fracture, the goals of treatment are to restore proper function by ensuring union of the fractured segments and re-establishing pre-injury strength, to restore any contour defect that might arise as a result of the injury, and to prevent infection at the fracture site [6].
Although there are doubts about the surgical indications for double mandibular fractures, it is not yet sufficiently clear what fractures should be treated first. This study aims to clarify, according to our experience, the correct surgical sequence which should be followed in order to treat these fractures.

Material and Methods

We conducted a retrospective research on our patient database, analyzing all the cases we have treated in our department because of double mandibular fracture.
We include only those cases in which the jaw was fractured in 2 segments, in particular patients who suffer a fracture in toothbearing areas (symphysis, parasymphysis, and anterior body) and also contralaterally in non toothbearing areas (posterior body, angle, ramus, and condyle). From January 2007 to January 2010, 47 patients met these criteria.
Eight of 47 patients (17%) were excluded from the study because 2 of them (4.2%) were lost to follow-up, and 6 (12.7%) were treated by intermaxillary fixation (IMF) only in 1 of the 2 fractured sites. Twenty-six (66.6%) of the 39 patients enrolled were male and 13 (33.3%) were female, and the mean age was 32.9 years.
Twenty-six (66.6%) patients had suffered the fractures following a road accident, 10 (25.6%) following an accidental fall, and 3 (7.7%) after fights. The non-toothbearing/toothbearing combinations of the fracture in our series were as follows: 23 (58.9%) patients had presented a condylar/parasymphysarian fracture, and 16 (41.1%) patients showed an angle/parasymphysarian fracture.
All patients were studied preoperatively by photographic documentation (mouth occlusion, mouth opening, and lateral and protrusive mandibular movements) (Fig. 1a, b), mandibular computed tomography (CT) scans without contrast (Fig. 2), and orthopantomography (Fig. 3).
The surgery was performed in all 41 patients by a standardized surgical technique. All patients were treated by open reduction and internal fixation (ORIF) using Synthes MatrixMANDIBLE plates and screws 2.0. and 2.3.
The sample was divided into 2 groups based on the fracture sequence of reduction. The first group (group A) consists of 22 patients (56.4%) who first received toothbearing area (symphysis, parasymphysis, and anterior body) reduction and fixation, and then were treated on the contralateral non-toothbearing area (posterior body, angle, ramus, and condyle) (Table I). The second group (group B) consists of 17 patients (43.6%) who received the reverse sequence of reduction (Table II). For toothbearing area, a transoral mucosal incision (inferior gingival fornix) was performed in all cases; for non-toothbearing area, a transcutaneous retromandibular approach in 20 cases (51.3%); a submandibular approach in 12 cases (30.8%) and a transoral approach in 7 cases (17.9%) were performed. In group A, the IMF was performed only preoperatively, in order to obtain open reduction and internal fixation much easier (Fig. 4). In group B, the ORIF was performed manually for the non-toothbearing fractures; we use the IMF in order to obtain reduction and fixation in toothbearing area (Fig. 5). All patients were followed up by observation 1, 3, 6, and 12 months after surgery. At each control, by using a millimeter ruler, the jaw functionality (mouth opening extension, mandibular laterality, and protrusion) were evaluated; furthermore, we assessed the facial nerve func-

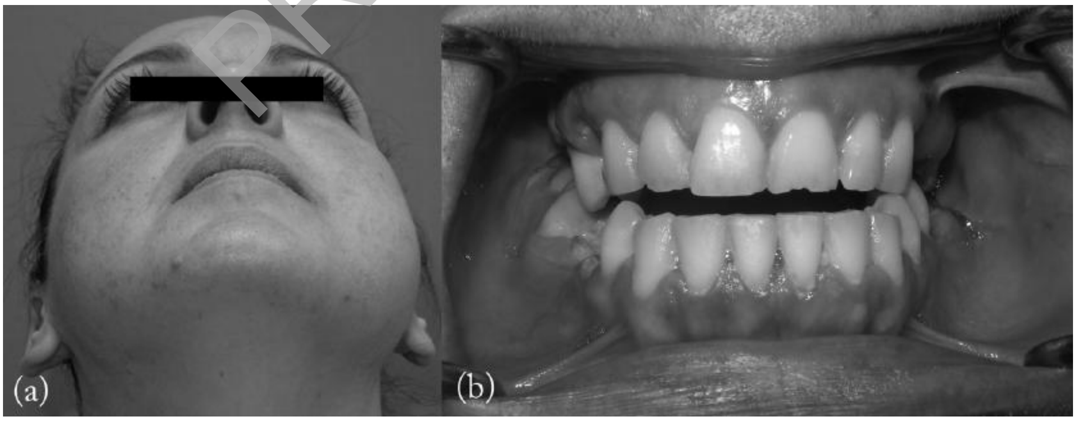

Fig. 1: Bifocal mandibular fractures: (A) facial aspect; (B) post-traumatic open bite.

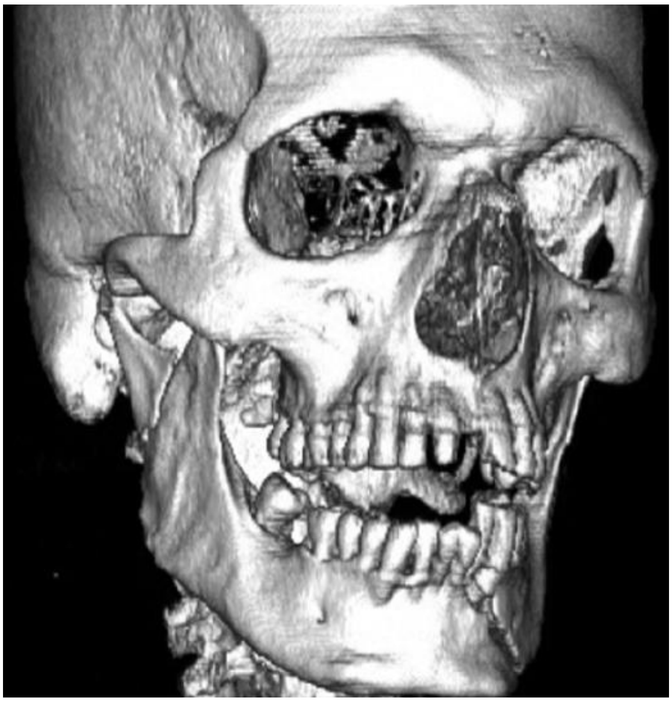

Fig. 2: Pre-operative cranio-facial 3D TC recostruction showing a parasymphisarian/sub-condilar mandibular fractures.

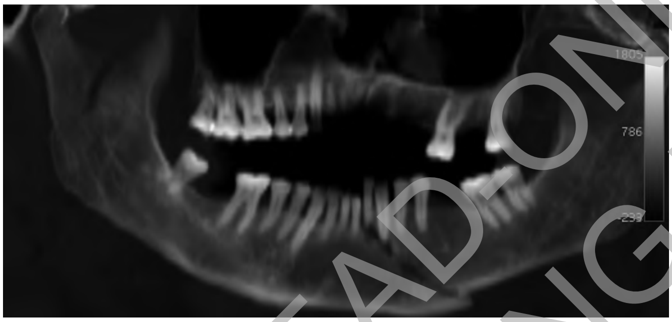

Fig. 3: Pre-operative orthopantomography showing a parasymphisarian/sub-condilar mandibular fractures.

Fig. 4: Group A intraoperative toothbearing open reduction and internal fixation (ORIF) after intermaxillary fixation (IMF).

Table I - *Group A Patient list*

N°	**Age**	**Sex**	**Type of fractures Nonthoobearing+Toothbearing**
1	33	M	Condyle + Parasymphesis
2	35	M	Condyle + Parasymphesis
3	61	F	Condyle + Ant. Body
4	25	M	Angle + Parasymphesis
5	44	F	Angle + Parasymphesis
6	27	F	Angle + Parasymphesis
7	25	M	Condyle + Parasymphesis
8	44	M	Angle + Parasymphesis
9	42	M	Angle + Parasymphesis
10	19	F	Angle + Parasymphesis
11	16	F	Condyle + Parasymphesis
12	14	M	Condyle + Parasymphesis
13	81	F	Condyle + Parasymphesis
14	68	M	Condyle + Parasymphesis
15	58	M	Condyle + Ant. Body
16	11	M	Condyle + Parasymphesis
17	25	F	Angle + Parasymphesis
18	24	M	Condyle + Parasymphesis
19	26	M	Condyle + Parasymphesis
20	28	M	Condyle + Parasymphesis
21	16	F	Condyle + Parasymphesis
22	42	M	Condyle + Parasymphesis

Table II - *Group B Patient list*

N°	**Age**	**Sex**	**Type of fractures Nonthoobearing+Toothbearing**
1	18	F	Condyle + Parasymphesis
2	16	M	Angle + Parasymphesis
3	63	M	Condyle + Parasymphesis
4	14	F	Condyle + Parasymphesis
5	29	M	Condyle + Ant. Body
6	15	M	Condyle + Ant. Body
7	26	F	Condyle + Ant. Body
8	39	M	Condyle + Parasymphesis
9	16	M	Angle + Parasymphesis
10	28	M	Angle + Parasymphesis
11	19	M	Condyle + Parasymphesis
12	16	F	Condyle + Parasymphesis
13	23	F	Angle + Parasymphesis
14	71	M	Angle + Parasymphesis
15	35	M	Condyle + Parasymphesis
16	70	M	Condyle + Parasymphesis
17	23	M	Condyle + Parasymphesis

tionality, the lip and chin sensibility, and the presence of temporomandibular joint pain and disocclusion. At first and 12th month, all patients were evaluated postoperatively by mandibular CT scans without contrast and orthopantomography to asses infected osteosynthesis materials and pseudarthrosis (or "nonunions").

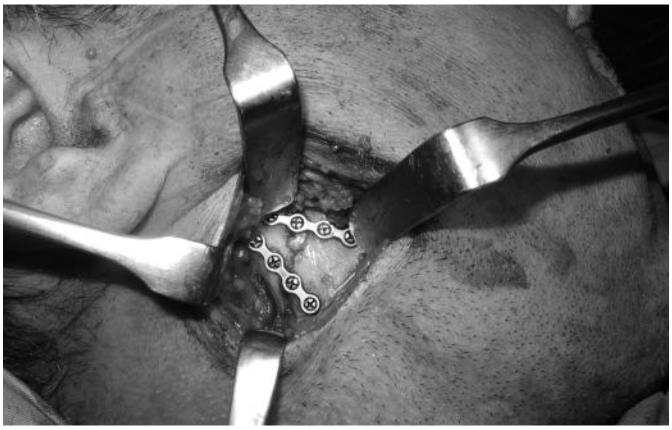

Fig. 5: Group B intraoperative non-toothbearing open reduction and internal fixation (ORIF) a retromandibular approach.

Fig. 6: Madibular asimmetry on submento-vertix projection

The operation time for each patient was calculated subtracting the ending time to the starting surgical time obtained by our records.
Data were processed using the RProject open source software for Statistical Computing version 2.14.1 released on December 22, 2011. For nonparametric data, X2 test was performed.

Results

Group A mean operation time was 99.8 (±28.0) min; patients had reduced operative time and an excellent postoperative outcome. In group B, in 3 cases (17.6%) it was necessary to remove intraoperatively titanium plates and screws already positioned to restore the mandibular continuity. At a 1-year follow-up, disocclusion associated with mandibular asymmetry occurred in 7 cases (41.2%) (Fig. 6) and pseudoarthrosis (or "nonunions") in 4 cases (23.5%).
In 3 cases (17.6%), a reduced mouth opening and restricted mandibular lateral and protrusive movements were observed (Fig. 7a-d). No facial and mandibular nerve deficits were observed at 1-year follow-up. In 6 patients (35.2%), a re-intervention was necessary to remove infected titanium screws and plaques. Operative time in group B was about 10.7 minutes longer compared to group A. In group A, 1 patient showed slight facial nerve deficit omolateral to the fractured site 1 year postoperatively (Table III). A non parametric χ^2 test for comparison of proportions was performed for each of the following outcome variable.

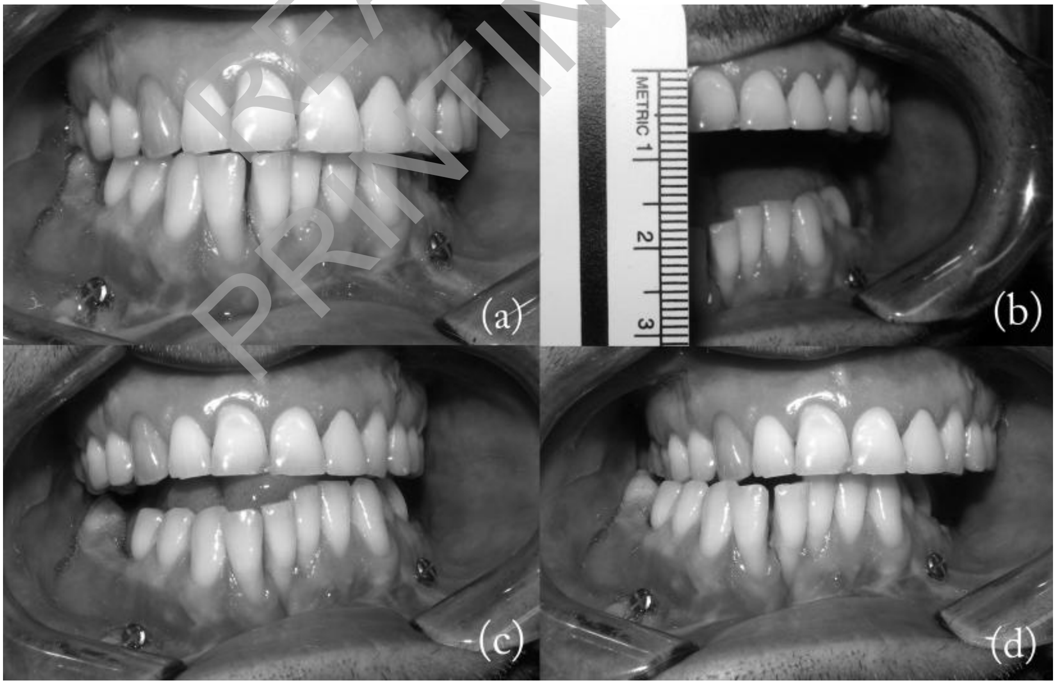

Fig. 7: a) mandibular disocclusion; b) reduced mouth opening and, c) restricted mandibular left and d) rigth movements.

TABLE III - *Main comparison variables between the two groups*

	One year post-operative outcomes						
	Operative time (min)	Disocclusion	Infected osteosynthesis materials	Pseudarthrosis	Limited jaw Functionality	Facial nerve deficit	Mandibular nerve (V_3) Iposensibility
A	99.8 (±28.0)	1	5	0	0	1	0
B	110.5 (±20.5)	7	6	4	3	0	0

For limited jaw functionality variable, the test shows a statistical χ^2= 4.206, with 1 degree of freedom, and a P value = 0.04028. Since the P value is less than 0.05, we reject the null hypothesis of equality of proportions; therefore, the data confirm the superiority of treatment A.
For the variable pseudarthrosis, the test provides a statistical χ^2= 5.768, with 1 degree of freedom, and a P value = 0.01632. Even in this case, the P value is less than 0.05, so we reject the null hypothesis of equality of proportions and confirm the superiority of treatment A.
For the variable disocclusion, the test produces a statistic χ^2= 7.892, with 1 degree of freedom, and a P value = 0.00497. In this case, since the P value is less than 0.05, we can reject the null hypothesis of equality of proportions, confirming the superiority of treatment A.

Discussion

In about half of all cases, mandibular fractures are multiple and, among these, most are double [1-3]. When a trauma occurs, the kinetic energy is transmitted along the mandibular arch; this causes a direct fracture on the impact site and an indirect fracture on a contralateral weakness point [7,8]. The site of the fracture and the vector of displacement are determined by the impact site, size, direction, and surface area of the impacting blow.
Hylander WL et al [10] studied the distribution of forces in the mandible following an impact; they found that when a force is directed along the parasymphysis/body region of the mandible, compressive strain develops along the vestibular aspect, whereas tensile strain develops along the lingual aspect. This produces a fracture that begins in the lingual region and spreads toward the vestibular aspect.
The mobile contralateral condylar process moves in a direction away from the impact point until it is limited by the bony fossa and associated soft tissue. Thus, tension develops along the lateral aspect of the contralateral non-toothbearing area, and a fracture occurs in the vestibular region and spreads toward the lingual aspect [4]. (Fig. 1)
According to this principle in all cases of our series we found that if an impact occurred in toothbearing region an indirect fracture occurs contralaterally in a non toothbearing area. Luyk et al [11] argued that condyles can dampen impacts up to a certain degree of intensity. When the kinetic energy exceeds the capacity of rotation of the condyle inside the glenoid cavity a non-toothbearing fracture occurs.
Huelke DF et al [12] in 1964 assessed the intensity of the kinetic energy needed to generate a double mandibular fracture. An impact to the chin with a line of force through the symphysis and temporomandibular joints will produce a single subcondylar fracture at 193 kg (425 lb.) and a bilateral subcondylar fracture at about 250 kg (550 lb.), whereas symphyseal fractures require force between 250 and 408 kg (900 lb) [26,27].
Mandibular fractures require the same principles applied for the treatment of bone fractures in general. Restoration of mandibular function, in particular as part of the stomatognathic system, must include the ability to masticate properly, to speak normally, and to allow for articular movements as ample as before the trauma.
Luyk demonstrated that Fixation requirements for double (or multiple) fractures differ from isolated fractures. [13]
When two fractures are present, there is a greater tendency for the segments to displace because of the bilateral loss of support that occurs. Widening of the mandible must be prevented by applying adequate internal fixation to resist that tendency [14,15].
If in literature it is now clear that the ORIF represents the most reliable pattern of treatment for bifocal fractures of the jaw, it is not the same regarding the ideal sequence of treatment for these fractures [16].
The analysis of our study results showed that, for the variables examinated, the treatment of fractures in toothbearing areas followed by the non-toothbearing areas, was characterized by fewer complications and significant reduction of operative time and costs.
When a non-toothbearing fracture was treated first, we found the reduction and fixation of the fractures much easier to perform. Actually, in group B patients, the non-execution of a rigid IMF for the non-toothbearing fractures, made bone segments more free to move but the absence of an occlusal guidance has made the reduction and fixation in toothbearing area much more difficult to perform. In 3 cases it was necessary to remove the means of osteosynthesis already positioned to restore the mandibular continuity. This may explain the higher inci-

dence of disocclusion and pseudarthrosis in group B patients. In group A patients, the restoration of the horizontal dimension (tooth-bearing fractures area) for first and consequently the proper occlusion allows to obtain a guide to re-establish the vertical dimension (non-toothbearing fractures area).

Conclusions

It is recommended from this study that reduction of the tooth-bearing fracture should be prior to the non-toothbearing one for the double mandible fractures. In our opinion, further studies are needed to confirm the data obtained and to better define the correct surgical sequence of treatment for these fractures.

Riassunto

Le fratture mandibolari costituiscono una quota che va dal 40% al 62% di tutte le fratture facciali. In circa la meta dei casi le fratture mandibolari sono multiple e tra queste una quota consistente presenta due rime di frattura. L'alta frequenza di fratture doppie è da attribuire alla particolare forma della mandibola. Da un punto di vista biomeccanico la mandibola può essere assimilata per grandi linee ad un arco le cui estremita sono costituite da condili. Tali strutture sono libere di ruotare all'interno delle cavità glenoidi assicurando in tal modo un certo grado di ammortizzazione in risposta ai traumi.
Nonostante non vi siano dubbi circa le indicazioni chirurgiche delle fratture mandibolari doppie non è ancora chiaro quale frattura dovrebbe essere trattata prima.
Lo scopo di questo studio è quello di chiarire, in base alla nostra esperienza, la corretta sequenza chirugica di riduzione da seguire nel trattamento delle fratture mandibolari doppie. Abbiamo condotto uno studio retrospettivo su un campione di pazienti operati presso il nostro reparto nel periodo compreso tra Gennaio 2007 e Gennaio 2010. Abbiamo incluso nello studio solo i pazienti trattati per doppia frattura mandibolare e li abbiamo suddivisi in due gruppi basandoci sulla diversa sequenza di riduzione delle fratture. I pazienti sono stati seguiti con uno stretto follow-up clinico e radiologico per valutare le variabili outcome di confronto tra i gruppi. L' analisi dei risultati ha evidenziato che i pazienti (gruppo A) in cui è stata ripristinata prima la dimensione orizzontale (frattura toothbearing) e poi quella verticale (non-toothbearing) hanno ottenuto minori complicanze postoperatorie e ridotti tempi operatori rispetto al gruppo di confronto (gruppo B). Il ripristino della dimensione orizzontale fornisce una guida per ottenere la riduzione efficace delle fratture non-toothbearing e il ripristino della dimensione verticale. In conclusione, sulla base della nostra esperienza e dei risultati ottenuti, in caso di fratture mandibolari doppie, gli autori suggeriscono la riduzione in prima istanza delle fratture toothbearing e successivamente qualle in area non-toothbearing.

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Commento e Commentary

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Il presente articolo mostra una particolare chiarezza di scopo, essendo incentrato su un argomento molto frequente nella pratica clinica maxillo-facciale.
La correttezza metodologica è supportata da un campione ben rappresentativo di casi omogeneamente trattati.
I risultati, compatibili con la letteratura, mostrano l'importanza di una corretta sequenza di trattamento chirurgico delle fratture mandibolari. La bibliografia supporta efficacemente il lavoro ed i suoi obiettivi. L'argomento trattato e la qualità del lavoro lo rendono di particolare utilità nell'attività del chirurgo maxillo-facciale.

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This article shows a particular clarity of purpose, being focused on a very frequent evenience in clinical practice maxillofacial surgery.
The correct approach is supported by a well-representative sample of cases treated homogeneously.
The results, consistent with the literature, show the importance of a correct sequence of the surgical treatment of mandibular fractures. The bibliography effectively supports the work and its objectives. The subject matter and the quality of work makes it particularly useful in the activity of maxillo-facial surgeon.