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Do mandibular miniplates increase the risk of complex fracture in facial trauma recurrence? Case series.

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Abstract

Whether to conserve or remove miniplates, widely used in oral and maxillofacial surgery, has not been agreed on in the literature. Complications such as pain, infection, and screw exposure or loosening have already been largely described. We present the consequences of a trauma recurrence on a mandible with miniplates. The data of 13 patients who had a mandibular fracture previously surgically treated with miniplates (ten mandibular fractures and three mandibular osteotomies) were analysed. All the patients were male; the average age was 32 years (range, 20-64 years). The mechanism of the second trauma was assault in most of the cases. The average time between the first osteosynthesis and the new fracture was 35 months (range, 6-128 months). The fractures occurred at a distance from the miniplates in all the cases except two. No plate fracture was reported. We hypothesised that miniplates reinforced the underlying bone, protecting it from fractures, and transmitted the forces to areas anterior or posterior to the miniplates or to the condyle. Thus, the risk of mandible trauma recurrence should be taken into account in the indication of plate removal, and the biomechanical consequences of the conservation of the miniplates should be studied.

Keywords

Mandible fracture; facial trauma; internal fixation; implant removal

Introduction

Since Champy (Champy et al. 1978) introduced their use, miniplates have been widely used in oral and maxillofacial surgery for osteosynthesis of mandibular fractures or mandibular osteotomies in orthognathic surgery. Osteosynthesis with miniplates favours bone healing (Gilardino et al. 2009), and most miniplates are made of titanium, which is well known for its biocompatibility (Breme et al. 1988). However, the attitude toward the conservation or the removal of the miniplates varies among authors. Some authors recommend a systematic miniplate removal, usually after 6 to 12 months (Park et al. 2016), whereas others reserve removal for those cases with clinical symptoms (Bhatt et al. 2005; Brown et al. 1989). Surprisingly, no study has dealt with the consequences of new traumas on mandibles with miniplates, despite the risk of mandible fracture recurrence. Indeed, Nygaard (Nygaard et al. 2018) and Mc Coy (McCoy et al. 2013) showed that 10% to 29% of facial traumas occurred after interpersonal violence recurrence, and as mandible fractures frequently occur after interpersonal assault (Lin et al. 2017; Olson et al. 1982), the risk of mandible fracture recurrence is anything but anecdotal. We hypothesise that the biomechanical behaviour of the mandible may be modified by the presence of the miniplates and may lead to more complex fractures in the case of trauma recurrence. Based on the description of a case series of fractures that occurred on mandibles with miniplates, we sought to describe and highlight the specificities and consequences of the recurrence of mandible fractures.

Case series

The inclusion criteria were the presence of mandibular miniplates for at least 6 months after fracture osteosynthesis or orthognathic surgery, a trauma recurrence on the mandible leading to a mandibular fracture identified on a computed tomography (CT) scan, and patient age of

18 years or more. The exclusion criteria were age less than 18 years and the presence of a mandibular plate for less than 6 months. The demographic data (age, sex), etiology of the initial mandibular osteosynthesis (location and type of miniplates), and new fracture type (circumstances, location based on CT scan) were recorded.

Thirteen patients from six French University Hospitals met the inclusion criteria. The results are summarised in Table 1. All the patients were men, and their mean age was 32 years (range, 20-64 years). The average time between the first procedure with the mandibular miniplate placement and the mandibular fracture was 35 months (range, 6-128 months). The indication of the former osteosynthesis was a fracture due to assault in nine cases, a horse hoof kick in one case, and a bilateral sagittal split osteotomy (BSSO) for correction of dental class II in three cases, including one with impaction genioplasty. In all the cases, the follow-up was uneventful and the former fractures healed well. The mechanism of the second trauma was assault in 10 cases, including the 9 cases who initially presented with a fracture due to an assault, a subsequent hoof kick for the patient who had been kicked initially, and a traffic accident for 2 patients treated with BSSO.

In 11 of 13 cases (19 of 21 fractures), the fractures occurred at a distance from the miniplates. In 2 of 13 cases, the fractures occurred under the former osteosynthesis. No miniplate fracture was reported. And, when two sites of osteosynthesis were present on the mandible, most of the new fractures (11/13) occurred to the opposite side of each osteosynthesis site.

Most of the fractures were bifocal (cases 1, 3, 4, 5, 6, 7, 9, 13) and presented as complex fractures, because they were either close to the former plates (cases 4, 9, 10, 12), were condylar (cases 1, 3, 5, 9), or were comminuted (cases 2 and 8).

Discussion

To our knowledge, this is the first retrospective study focusing on the behaviour of mandibles with miniplates in the case of trauma recidivism. Mandibular miniplates changed the biomechanical behaviour of the mandible, reinforcing the area under the miniplates and transmitting the forces to the areas that were not reinforced, leading to complex fractures that are condylar, close to the former miniplates or comminuted. Thus, our findings provide an argument to remove miniplates in certain cases.

A literature review allowed us to identify two case series focusing on mandible fracture recurrence (Agir et al. 2005; Elrasheed et al. 2011) (table 2). These two studies included patients presenting a mandible fracture recurrence, that is, the first event was a mandible fracture in all the cases. A total of 21 patients experienced a recurrence of a mandible fracture, and one patient experienced two recurrences. Four patients were treated conservatively after their first fracture and did not have a mandibular miniplate at the time of the second trauma. All the patients were male, the mean age was 31 years (range, 21-60 years), and the average time between the first and the second fracture was 54 months (range, 3-180 months). When the patient was previously treated by open reduction and internal fixation (ORIS), in all the cases (23 fractures), the fractures occurred at a distance from the miniplates. No miniplate fracture was reported. The fracture recurrences were bifocal in 4 of 18 cases. The fracture recurrences were on the opposite side of the osteosynthesis site in 6 of 23 fractures, close to the miniplates in 7 of 23 fractures, and involved the condyle in 6 of 23 fractures. In the four patients who had undergone a conservative treatment or an intermaxillary fixation (IMF) for the first fracture, and consequently did not have a miniplate when the recurrence occurred, the fracture recurrences (five fractures, one patient presented a bifocal fracture) were at a distance from the first fracture in all cases, and on the same site but

on the other side in 3 of 5 cases.

The aim of these studies was to describe the features of a mandible fracture recurrence, whereas our study focused on the impact of the miniplates on mandible fractures.

Consequently, the inclusion criteria were different. In the studies of Agir et al. and Elrasheed et al., the patients presented with a mandible fracture as the first event in all the cases, with or without open reduction and internal fixation, whereas in our study, the first event could be a mandible fracture or a mandible osteotomy, with an internal fixation in all the cases.

Moreover, the internal fixation data were more accurate in our study (location, number, thickness of the miniplates and number of screws) to describe the patterns of fracture with regard to the osteosynthesis technique. Nevertheless, these two studies supported the results of our cohort regarding epidemiological data and the fractures' trend of recurring away from the miniplates.

Epidemiological considerations demonstrated that the recurrence of facial trauma was common. In particular, young males are more at risk for facial trauma (Lin et al. 2017; Olson et al. 1982), which was confirmed in our study, because all recurrences were in young men. According to the literature (Agir et al. 2005; Olson et al. 1982), the primary cause of mandibular fracture in our study was assault for the first trauma as well as the recurrence. And, maxillofacial trauma recurrence is particularly frequent in the case of assault. Indeed, McCoy et al. (McCoy et al. 2013) demonstrated that the recidivism rate of facial trauma increased to 29.3%. Among these recurrences, the highest portion was due to assault. In the same way, Nygaard et al. (Nygaard et al. 2018) showed that among the patients admitted to a trauma centre, nearly 10% were admitted for a recurrence of trauma. Thus, the risk of mandibular fracture recurrence, particularly among young men who have been victims of

assault, must not be overlooked.

Our study showed that miniplates protect the osteosynthesis area from fracture recurrence, but promote fracture at a distance. Mostly (19 of 21 fractures), the new fracture occurred at a distance from the miniplates, and no miniplate fracture was reported.

The new fracture occurred under the plate in only two cases (cases 7 and 12). In these cases, the miniplate, located on the external oblique line (Champy's technique), protected the angle from tension force due to mastication (Champy et al. 1978), but not from force due to an anterior or a lateral impact. Moreover, in case 7 (Figure 1), the angle was weakened by an impacted third molar (Nogami et al. 2018). In case 12, the new fracture occurred through the distal root of the third molar, known to be an area of weakness, and perhaps explaining the fracture recurrence at the same place, under the miniplate, but without miniplate fracture. In these two particular cases (cases 7 and 12), the miniplates avoided damage from the fracture displacement.

Considering the locations of the former miniplates and the new fractures, we hypothesised that the miniplates reinforced the underlying bone and transmitted the forces to the area that was not reinforced, posteriorly (cases 4 and 10), anteriorly (case 9) (Figure 2), or contralaterally (cases 1, 2, 4, 6, 7, 8, 13), eventually promoting atypical fractures or complex fractures due to the proximity of the former miniplates (cases 2, 4, 8, 9, 10) or the condyle (cases 1, 3, 5, 9). For example, in case 4 (Figure 3), the fracture occurred on the right parasymphysis distal to the miniplates, and therefore distal to the canine root. The canine root area is a known weakness area (Park et al. 2018), and the fracture was expected to occur next to the canine root and not posteriorly, if miniplates had not reinforced this area. Likewise, in case 10 (Figure 4), the fracture occurred posteriorly to an adjustable miniplate after a BSSO.

In this case, a lateral impact broke the mandible just posterior to the osteosynthesis area, because it was reinforced by the osteointegration and the rigidity of the miniplate. We can assume that the fracture would have occurred more anteriorly if the miniplate was not present, and its treatment would be facilitated by the anterior position and the lack of the former plate. Indeed, the proximity of a fracture with miniplates complicates its management, because of the need to remove the miniplates to be able to fix the new fracture. First, the surgeon needs to know the brand of instrument set if the miniplates were placed in another centre; second, the surgeon must have this instrument set available; third, the incision and the subperiosteal elevation have to be extended to the former osteosynthesis area, increasing the risk of nerve or vascular injury; and fourth, the miniplates may be osteointegrated, and thus difficult to remove. Elrasheed et al.(Elrasheed et al. 2011) showed that, following a mandible fracture recurrence, more than half of the patients presented one or more complications: malocclusion, postoperative infection, osteomyelitis, and malunion. The presence of the former miniplates could interfere with the placement of the new miniplates leading to a non-optimal fixation and a risk of malunion. The removal of the former miniplates by increasing the surgery duration, the subperiosteal elevation, the incision length, and the need for an osteotomy could expose to the risks of postoperative infection, osteomyelitis and malocclusion. Thus, the impact of the presence of miniplates close to the fracture must not be minimised.

Taking into account the previous observations, we can postulate the consequences of a trauma recurrence on a mandible with miniplates at the parasymphysis or angle, the most frequent sites of extra condylar mandibular fractures (Olson et al. 1982). Depending on the impact point, parasymphysis miniplates could promote a contralateral parasymphysis fracture

or a fracture near the miniplates. These hypotheses were confirmed in cases 1 and 6, and one case in the literature review showing a contralateral parasymphysis fracture, and in case 4 and in three cases in the literature review, a homolateral body fracture. Likewise, angle miniplates could promote a contralateral angle fracture [as in cases 4, 6, 7, 13 and three cases in the literature cohorts (Agir et al. 2005; Elrasheed et al. 2011)], an anterior ipsilateral body fracture (as in cases 2 and 11 and three cases in the literature cohorts), or a posterior ipsilateral condyle fracture (as in case 5 and three cases in the literature cohorts).

In cases of particular osteosynthesis, such as Champy's technique for angle fracture and BSSO miniplate, the new fractures were associated with ipsilateral condyle fracture in half of the cases, when the impact was anterior. Indeed, the external oblique line miniplate (anterior in BSSO, posterior in angle osteosynthesis) may promote the transmission of forces to the condyle in the case of an anterior impact. For example, in the case of BSSO osteosynthesis using one plate on each external oblique line, the new fractures occurred on the two bases of the condyle processes (case 3) and on the right head of the condyle (case 9).

Only four patients, in the literature cohort, showed a fracture recurrence without former mandibular miniplate, and only two fractures involved the horizontal portion of the mandible. The fracture recurrences at a distance from the former fracture, in all the cases, were not in favour of a bone weakness in the previous fracture areas and may reduce the impact of the miniplates in the biomechanical behaviour of the mandible. However, the low sample did not allow findings to support this observation.

Finally, aside from the consequences of the miniplates in a trauma recurrence, the most important issue remains: should the mandibular miniplates be removed? Indeed, the removal of the miniplates in oral and maxillofacial surgery is still debated. Some authors recommend

the systematic removal of the plates (Alpert and Seligson 1996), whereas others propose to remove them only if the plates become symptomatic or induce a complication (Park et al. 2016)(Sukegawa et al. 2018). The literature reported pain, infection, screw loosening and exposure, the need for dental rehabilitation, tooth removal, and patient request (Rallis et al. 2006; Vos and Verhofstad 2013) as usual causes of miniplate removal. Looking at the literature, we noted that implant removal is also discussed in orthopaedics (Kasai et al. 2019) with more or less the same arguments. On the one hand, metal toxicity, carcinogenicity, and metallosis are situations that favor implant removal; and on the other hand, the high complication rate associated with implant removal, the cost, and the necessity of general anesthesia make practitioners reconsider a systematic implant removal attitude.

Metal toxicity in the form of implant-related sarcoma (Adams et al. 2003) has been rarely described in both orthopaedic implants and dental implants (McGuff et al. 2008). However, animal studies suggest that titanium has a low risk of carcinogenicity (Takamura et al. 1994). The metal debris of titanium-aluminum-vanadium (TiAlV) has been shown to result in chromosomal damage (Dennison 2010), but it is uncertain whether this chromosomal damage could result in any mutagenic changes in tissues surrounding these metals (Daley et al. 2004). Moreover, these results were obtained with implants used in a friction area, such as the hip and knee. Because the amount of titanium released depends on implant wearing and fretting, we can expect that mandibular miniplates, which are extra-articular, release little titanium. The serum level of metal has been investigated in orthopaedic implants with contradictory results, and levels have been sometimes elevated for titanium (Kasai et al. 2003), or not (McGarry et al. 2008). No study evaluated the titanium serum level in mandibular miniplates. However, taking into account their small size and the lack of friction, a low titanium serum level could be expected. It seems reasonable to conclude that the titanium mandibular miniplates can be retained with an acceptable level of risk of toxicity.

In orthopaedics, the complication rate associated with implant removal is as high as 19% (Kasai et al. 2019) depending on the anatomic location and the surgeon's experience. The complications included infection, arterial injury, nerve injury, and skin necrosis. Mandibular miniplate removal could also be responsible for infection, haematoma, and inferior alveolar nerve injury (Bhatt et al. 2005; Mosbah et al. 2003). This potentially high rate of complications must be taken into account in the implant removal decision and be explained to the patient.

The fear of a more complex fracture is also mentioned in the orthopaedics literature. Peri-implant fractures occur mainly through peripheral screw holes (Labosky et al. 1990). A reason for the peri-implanted fracture might be a higher rate of vascular disruption in open plate osteosynthesis (Acklin et al. 2018). Even if cortical osteopaenia has principally been described for large plates, it had been reported under asymptomatic miniplates (Alpert and Seligson 1996). However, our study was not in accordance with the description of plate-associated fracture (Alpert and Seligson 1996) due to cortical osteopenia caused by vascular shielding under plates (Kennady et al. 1989a, 1989b). In our cases, the miniplates tended to reinforce the area of the miniplate and to promote fractures at a distance from the miniplate and not under the miniplate. The risk that the implant itself complicates the outcomes of a new fracture, in case of trauma recurrence, has already been discussed in orthopaedics (Acklin et al. 2018) and for the orbit (Foletti and Scolozzi 2017) in maxillofacial trauma surgery. Foletti and Scolozzi (Foletti and Scolozzi 2017) showed that the deformation of an orbital titanium mesh in the event of traumatic recurrence may transform it into a penetrating object with the potential to threaten the surrounding structures. Nevertheless, the authors did not recommend systematic removal of orbital implants because of the complications induced by a new incision into the eyelid, but they considered this risk to be disclosed in the information given to patients. The issue is different in the mandible, where the miniplates do

not directly threaten the surrounding tissues due to their deformation, but lead to complex fracture or make the treatment of the new fracture more difficult, and where oral incisions are not associated with the same morbidities. The removal of the mandibular miniplates could be more easily proposed in case of risk of fracture recurrence. The information given to the patient must evolve in the same direction.

In our case series, no guideline allowed us to determine if plate removal was required before the trauma recurrence. Regarding its morbidity, cost, and the probable absence of toxicity, systematic removal of miniplates should not be recommended in the absence of the previous symptoms. However, mandibular biomechanical changes related to miniplates in cases of trauma recidivism, with the risk of fracture recurrences close to the former miniplates with an increased risk of complications or condyle fractures more complex of to treat, could be a new argument in favour of miniplate removal in some cases, at least in the population who is at risk of recurrence.

Our study had limitations because of its descriptive and retrospective nature. A prospective study should be performed, but is difficult to conduct due to the low frequency of cases.

Conclusion

This study emphasised the modifications of mandibular biomechanics in cases of trauma recidivism, and the potential consequences of not removing mandibular miniplates, particularly in young males with a mandibular fracture due to an assault, including the risks

of fractures involving the condyle and the areas close to the former miniplates, which are more difficult to manage and associated with a higher complication rate.

Going forward, this potential risk of complex fracture recurrence should be disclosed in the information given to patients.

Ethics statement

This study was in accordance with the Declaration of Helsinki and received the approval of Aix Marseille IRB (n°2020-01-05-02).

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Conflict of interest

The authors have no financial disclosures or conflicts of interest to declare.

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Tables

Table 1: Characteristics of the study sample

Cases: Age/Sex	Etiology first fracture	Etiology new fracture	Delay (months)	Former miniplates position and characteristics	New Fractures locations
1: 40/M	Assault	Assault	13	<ul style="list-style-type: none"> - Right condyle neck 1 subcondylar trapezoidal miniplate 1.0 mm - monocortical screws - Left parasymphysis 2 four-hole 1.0-mm miniplates - monocortical screws 	<ul style="list-style-type: none"> - Left condyle neck - Right parasymphysis
2: 26/M	Assault	Assault	9	<ul style="list-style-type: none"> - Right angle 2 four-hole 1.0-mm miniplate - monocortical screws - Left parasymphysis 2 four-hole 1.0-mm miniplate - monocortical screws 	<ul style="list-style-type: none"> - Right body comminuted
3: 40/M	Bilateral sagittal split osteotomy	Car accident	6	<ul style="list-style-type: none"> - Right osteotomy 1 four-hole 0.8-mm adjustable miniplate - monocortical screws - Left osteotomy 1 four-hole 0.8-mm adjustable miniplate - monocortical screws 	<ul style="list-style-type: none"> - Right condylar neck - Left condylar neck

4: 25/M	Assault	Assault	17	- Right angle 1 angled six-hole 1.25-mm miniplate - monocortical screw - Right symphysis 2 four-hole 1.0-mm miniplate - monocortical screws	- Left angle - Right parasymphysis (posterior to the miniplates)
5: 27/M	Assault	Assault	24	- Left angle 1 four-hole 1.0-mm miniplate - monocortical screws	- Left condyle - Right symphysis
6: 28/M	Assault	Assault	36	- Right angle 2 four-hole 1.0-mm miniplate - monocortical screws - Left parasymphysis 2 four-hole 1.0-mm miniplate - monocortical screws	- Left angle - Right parasymphysis
7: 20/M	Assault	Assault	20	- Right angle 1 four-hole 1.0-mm miniplate - monocortical screws - Left parasymphysis 2 five-hole 1.0-mm miniplate - monocortical screws	- Left angle - Right angle
8: 64/M	Hit with a horse shoe	Hit with a horse shoe	36	- Right body 1 nine-hole 1.0-mm miniplate - monocortical screws 1 four-hole 1.0-mm miniplate - monocortical screws	- Left body Comminuted
9: 30/M	Bilateral sagittal split osteotomy genioplasty	Bike accident	128	- Right osteotomy 1 four-hole 1.0-mm miniplate - monocortical screws - Left osteotomy 1 four-hole 1.0-mm miniplate - monocortical screws - Genioplasty One 16-mm compression screw	- Right capital condylar - Symphysis (through the genioplasty screw)
10: 20/M	Bilateral sagittal split osteotomy	Assault	24	- Right osteotomy 1 four-hole 0.8-mm adjustable miniplate - monocortical screws - Left osteotomy	- Left angle

				1 four-hole 0.8-mm adjustable miniplate - monocortical screws	(posterior to the miniplate)
11: 38/M	Assault	Assault	36	- Right angle One four-hole 1.25 mm miniplate - monocortical screws - Left parasymphysis 2 miniplates removed before the second trauma	- Right body through second molar
12: 29/M	Assault	Assault	120	- Right subcondylar 2 four-hole 1.0-mm miniplate - monocortical screws - Left angle 1 four-hole 1.0-mm miniplate - monocortical screws	- Left angle (under the miniplate)
13: 30/M	Assault	Assault	24	- Left angle 2 four-hole 1.0-mm miniplate - monocortical screws - Right horizontal branch through first molar 2 four-hole 1.0-mm miniplate - monocortical screws	- Right angle - Left horizontal branch through the first molar

Table 2: Mandible fracture recurrences in the literature.

Study	<i>N</i>	Mean age (years)	First fracture etiologies	First fracture treatment	Mean time during fractures (months)	Fracture recurrence etiologies
Agir et al. 2005	9	29 [22-45]	-	ORIF: 8 Conservative 1	66 [6-153]	-
Elrasheed 2011	13 (1 with 2 recurrences)	32 [21-60]	Assault: 9 MVA: 3 Sports: 1	ORIF: 9 IMF: 2 Conservative 1	46 [3-180]	Assault 11 Sports: 3

MVA: Motor Vehicle Accident; ORIF: Open Reduction and Internal Fixation; IMF: Inter Maxillary Fixation

Captions to illustrations

Figure 1: Case 7: 3D Reconstruction based on facial CT scan showing: A. a left angle non-displaced fracture (red arrow) under a 1.0-mm miniplate, after an anterior impact. B. The contralateral angle fracture (blue arrow) (posterior to a left parasymphysis osteosynthesis with two 1.0-mm miniplates) is displaced, while avoiding the displacement of the left angle fracture recurrence.

Figure 2: Case 9: Axial CT scan reconstruction showing: A. a case of anterior impact, an atypical symphysis fracture, with a fracture line running through the compression symphysis screw (red arrow) and then to the right parasymphysis and internal cortical. The compression screw weakened the symphysis or transmitted stress along its path. B. The fracture line then extended posteriorly in the right internal cortical to the right parasymphysis (blue arrow). The right miniplate reinforced the external cortical split and promoted the internal cortical split.

Figure 3: Case 4: 3D Reconstruction based on facial CT scan showing: A. a case of right anterior impact, a right parasymphysis fracture (red arrow) posterior to two 1.0-mm miniplates, which reinforced the canine root area, B. whereas the right angle 1.25mm miniplate promoted a contralateral angle fracture (blue arrow).

Figure 4: Case 10: 3D Reconstruction based on facial CT scan showing a case of lateral impact, a fracture (red arrow) just posterior to the 0.8-mm adjustable plate. The area of this osteosynthesis is reinforced by the miniplate.

WL: 360 WW: 162

S

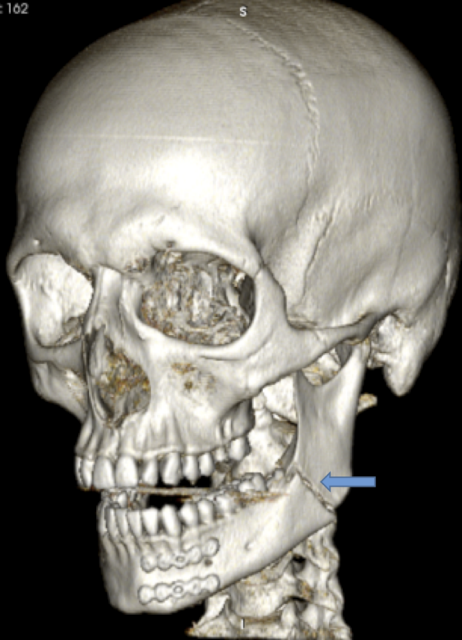
RA

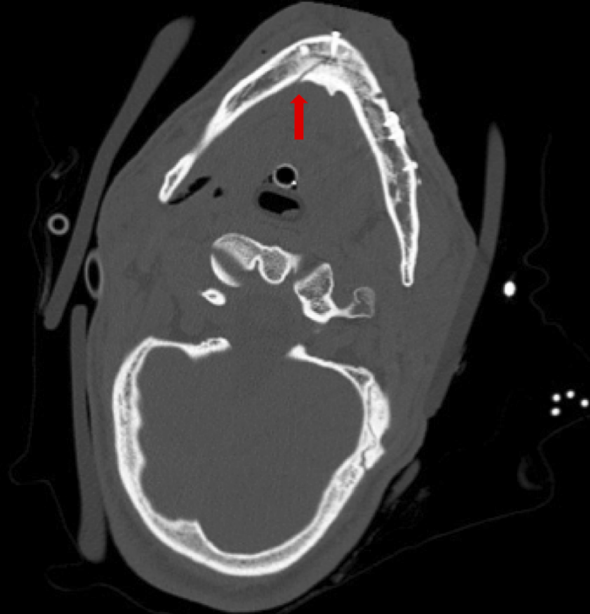
RP

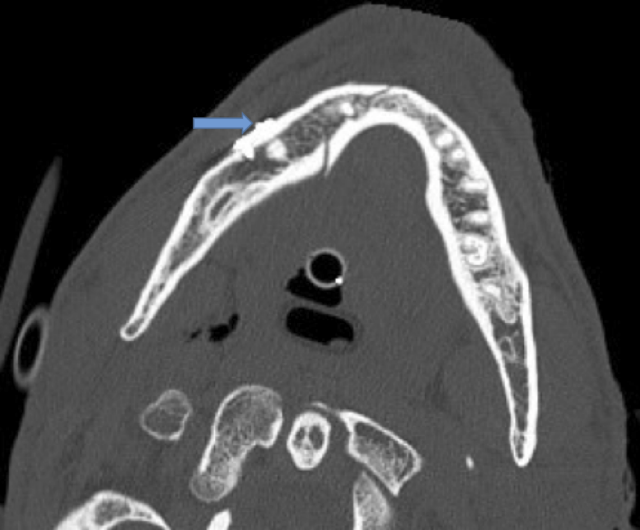
LA



S-I: -5.8
L-R: -33.7
Rot: 8.4







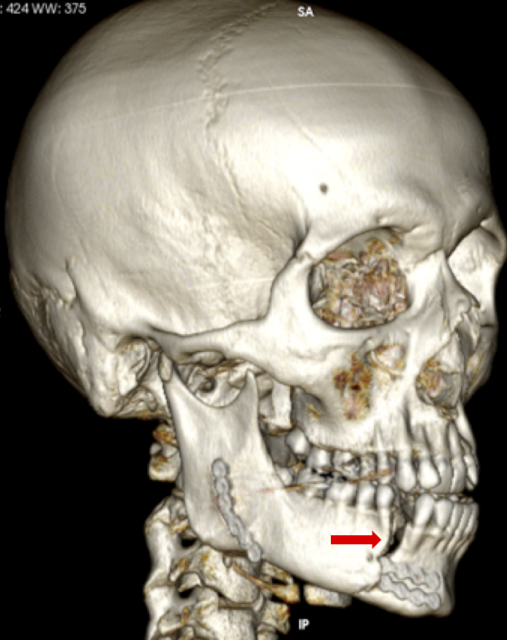
WL: 424 WW: 375

SA



PR

AL



IP

S-I: -14.7
L-R: -46.7
Rot: 6.1

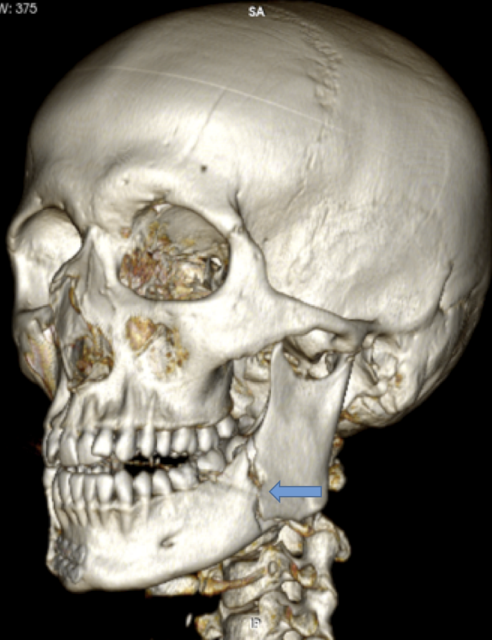
WL: 424 WW: 375

SA



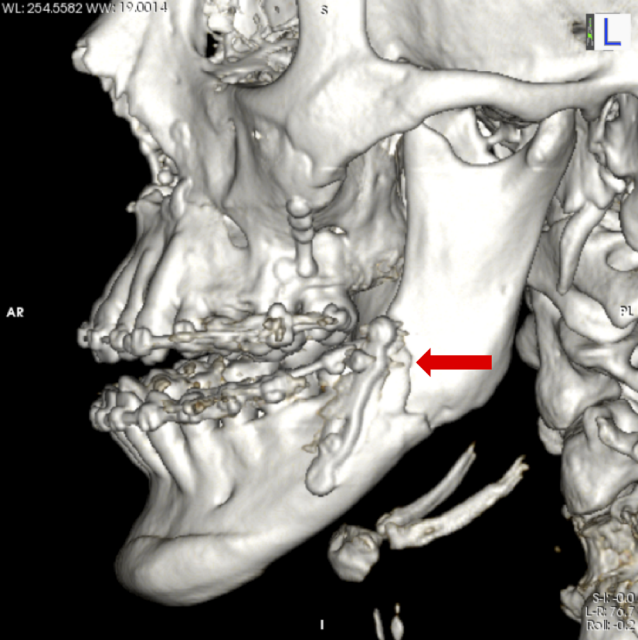
RAI

LPS



S-I: -13.1
L-R: 44.6
Rot: -17.1

F



L

S

AR

PL

S-I: 0.0
L-R: 76.7
Roll: -0.2