OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE
Craniofacial/Pediatric

Versatility of Hard Occlusal Splints in Optimizing Outcomes in Patients with Old Pan-facial Fractures

Mohammed Ahmed Hussein, MD, PhD
Abdelaziz Besher, MD, PhD
Mohammed Aly Saad, MSc
Adel Michel Wilson, MD, FRCS

Background: Pan-facial fracture repair is considered one of the most challenging complex reconstructive procedures to perform. It is always better to treat facial fractures as soon as possible. A delay of several days or weeks makes an ideal anatomic reduction difficult, if not impossible.
Methods: Patients presenting late with noncompound pan-facial fractures and interrupting maxillary and mandibular arches who were candidates for ORIF were included. Patients had been divided randomly into two groups: group A was managed by the ordinary sequence of repair, and group B was managed with the aid of occlusal dental splint.
Results: In total, 20 patients presented late (3–9 weeks post insult) due to serious injuries that required previous intervention. The time until obtaining optimal occlusion ranged between 80 and 120 minutes in the study group, whereas in the control group, the time ranged between 120 and 180 minutes ($P < 0.0001$). Postoperative malocclusion was noticed to be less frequent in the splint group than in the control group: only one patient with residual malocclusion in the study group versus two patients in the control group.
Conclusions: Occlusal splints could be a good modality for restoring the pre-morbid occlusion in patients with delayed pan-facial fractures. It is a simple, reliable technique that could be easily integrated into our daily practice, and could help decrease the intraoperative time needed for restoration of optimal occlusion and decrease the postoperative malocclusions. *(Plast Reconstr Surg Glob Open 2021;9:e3855; doi: 10.1097/GOX.0000000000003855; Published online 8 October 2021.)*

INTRODUCTION

The term "pan-facial" is commonly used to describe complex fractures involving multiple facial bones, whose degree of fragmentation made the restoration of pre-injured architecture a difficult task.[1]

Manson et al have divided the facial skeleton into four anatomic areas: the frontal area, the upper midfacial area, the lower midfacial area, and the mandibular area. According to his classification, the midface had been divided into upper and lower segments in relation to the Le Fort I level. Those authors believed that true pan-facial fractures could be distinguished from multiple facial fractures in relation to the Le Fort I level. True pan-facial fractures are those fractures that involve segments on both sides of Le Fort I level, while multiple fractures involve more areas in one half of the face.[2] In contrast, Follmar et al defined pan-facial fractures as fracture patterns that involve at least three of four axial segments of the facial skeleton: frontal, upper midface, lower midface, and mandible.[3]

Patients with pan-facial fractures represented a small proportion of the overall population with facial fractures. These fracture patterns are usually associated with high-energy trauma that usually results in severely comminuted fractures, dramatic instability, and marked alteration in facial skeletal architecture. These injuries included road traffic accidents, interpersonal violence, sports-related accidents, industrial accidents, and gunshot wounds.[4,5]

Pan-facial fracture repair is considered one of the most complex and challenging reconstructive procedures to perform. According to Ellis et al, it is always better to treat facial fractures as soon as possible. A delay of several days or weeks makes an ideal anatomic reduction of the

From the Department of Plastic and Reconstructive Surgery, Faculty of Medicine, Cairo University, Cairo, Egypt.

Received for publication March 1, 2021; accepted August 16, 2021.

DOI: 10.1097/GOX.0000000000003855

Disclosure: *The authors have no financial interest in relation to the content of this article. The study did not receive any funding.*

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

fracture difficult, if not impossible. So, surgery could be performed either very early, or after 5–7 days when the edema subsides.[6]

This study aimed to evaluate the efficacy of dental splints to restore optimal premorbid occlusion in late presented pan-facial fractures.

PATIENTS AND METHODS

Following institutional ethical committee approval, 20 patients (19 men and one woman) presented with late noncompound pan-facial fractures, and interrupting maxillary and/or mandibular arches were included. Patients were candidates for ORIF. Young patients (<16 years old) or elderly patients (>60 years old), edentulous patients, patients with presence of lost bony segment, and comatose patients were excluded from our study.

Patients had been divided randomly into two groups according to the sequence of their presence: Odd numbers (group A) were managed by the ordinary sequence of repair; even numbers (group B) were managed with the aid of occlusal dental splint.

Preparation of the Hard-occlusal Splint

Forty-eight hours before surgery, alginate impressions were obtained from the patient's dental arches that were free of voids. A snap removal from the mouth is recommended, as rocking upon removal causes distortion and tearing, and leads to an ill-fitting appliance. Short-acting sedation was used to permit pain-free mouth opening and obtaining these impressions.

Pouring of the impressions immediately into resin rock was done to obtain both the maxillary and mandibular casts (Fig. 1).

The casts were sectioned at the site of the fractures according to the patient's radiology. The three-dimensional (3D) reconstruction imaging provided good visualization of both dental arches and the extent of the fracture lines. The fractured segments were reduced and stabilized by baseplate wax.

Takeaways

Question: Do hard occlusal splints improve the outcome in patients with late presented pan-facial fractures?

Findings: The study showed decreased operative time and improved outcomes regarding the incidence of malocclusion postoperatively.

Meaning: Hard occlusal splints significantly decrease operative time in patients with old pan-facial fractures, and improve outcome as well as decrease the incidence of postoperative malocclusion.

The casts were mounted on the articulator (Fig. 2) to bring them into the predicted pre-injury occlusion depending on the dental facets and cusp interactions, and acrylic splint was fabricated in this relation. Holes could be drilled at the interdental region to allow the passage of wires for mandibular–maxillary fixation (MMF). This fabricated dental splint mimics the patient's pre-injury occlusion, which could be used during surgery as a template bringing the fracture segments together into the proper relation, leading to a good occlusion. This whole process takes on average between 3 and 4 hours; most of this time is consumed by preparing the material and waiting for the casts to dry.

Operative Sequence

After accessing the fracture sites, fractured segments were disimpacted and mobilized with clearing the sites for adequate reduction. After mobilization of the maxillary and mandibular fracture segments, the splint was applied as a template, where all fractured segments passively guided into, bringing the dental arches into their proper relation and dimension, and hence, a proper occlusion.

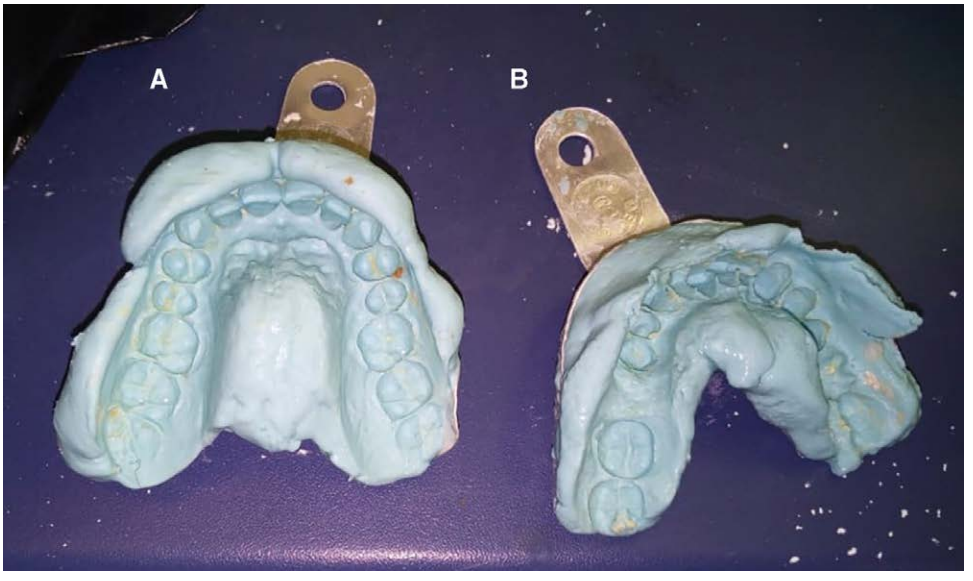

Fig. 1. Close photography of the maxillary cast with the palatal impression (A) and the mandibular cast (B).

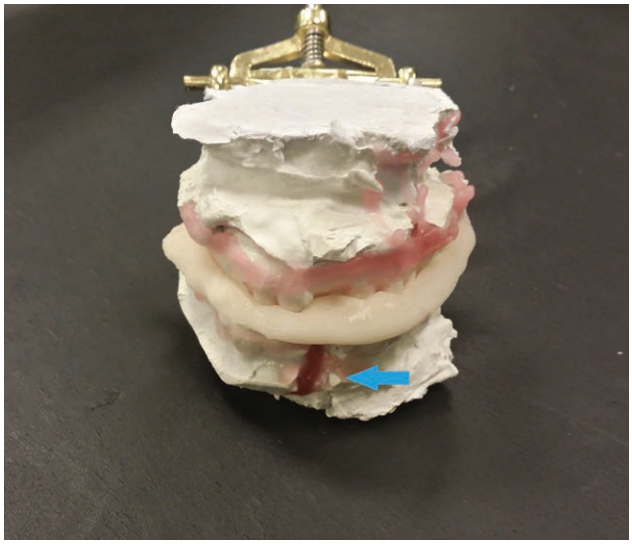

Fig. 2. Mounting of the casts on the articulator. The arrow indicates the site of the fracture, which is stabilized by the wax to obtain optimal dental relation. The occlusal splint is then prepared in vitro.

(**See figure, Supplemental Digital Content 1,** which displays frontal (a) and oblique views (b, c) of the MMF with the occlusal splint, which guides the dental arches into a good occlusion. **http://links.lww.com/PRSGO/B799**.) Temporary stabilization of the fractures along with the interdental splint through the MMF. Time from the start of surgery till reaching the proper stable occlusion was calculated. To avoid any bias in time calculation, time was standardized for mandibular fractures' exposure through one or two lower buccal sulcus incisions, complete midface exposure to infra-orbital rim bilaterally through upper buccal sulcus incision, complete mandibular and maxillary fracture disimpaction, and MMF by IMF screws, also. All procedures were done by the first author and time was calculated on stop-watch. Time consumed for any other incisions or procedures was excluded.

The maxillo-mandibular unit was considered the starting point from which the reconstruction of the facial skeleton proceeded. After completion of osteosynthesis, the splint was removed, and the occlusion was released and double-checked without MMF, then all wounds were closed. In Patients with palatal fractures, the splints were re-applied and fixed to the upper jaw and kept in place for 4 weeks to avoid any transverse relapse. In some patients in whom we could not get rigid fixation, we kept the patient in occlusion for 4 weeks using elastics.

Six weeks postoperatively, the patients were assessed for adequacy of occlusion both subjectively and objectively; patients were asked to assess whether the occlusion felt consistent with the premorbid state or not. Also, the patient was examined clinically and radiologically by the senior author to determine the adequacy of occlusion. We adopted the description of the class I occlusion of Angle's classification to define adequate occlusion postoperatively.

The collected data were coded, tabulated, and statistically analyzed using IBM SPSS statistics software, version 18.0 (IBM Corp., Chicago, Ill., 2009).

RESULTS

Twenty patients (19 men and one woman) who presented to our department and met our inclusion criteria were included in this study (Fig. 3). Patients were randomly divided into two groups: patients assigned an odd number represented the control group (group

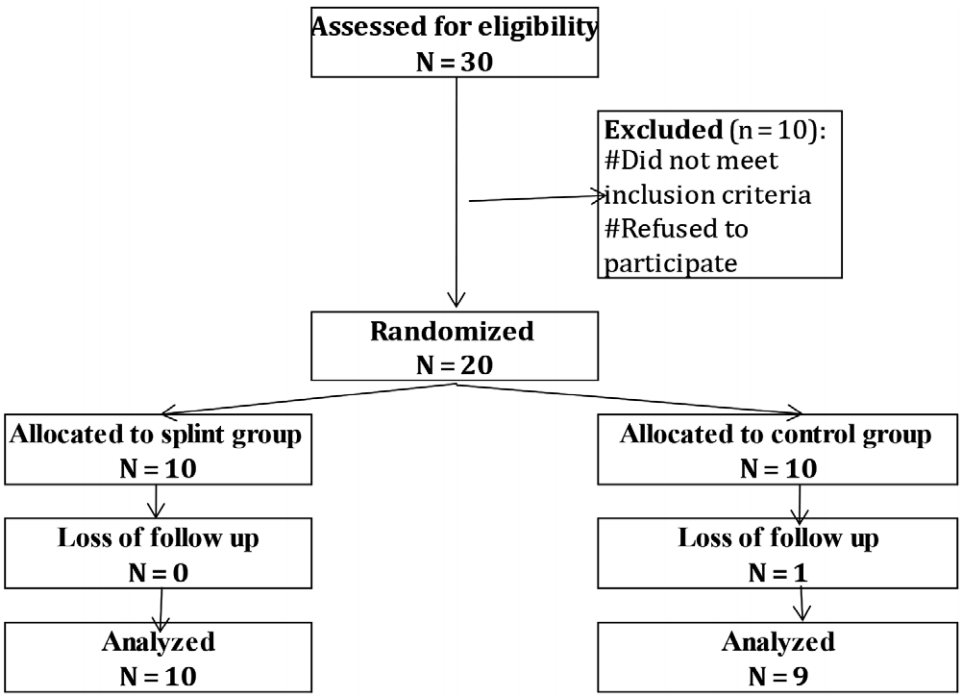

Fig. 3. Flow chart of the studied cases.

A), whereas patients of even number represented the study group (group B) where the occlusal splints were used (Fig. 4) (Table 1). (**See figure, Supplemental Digital Content 2,** which displays preoperative frontal view of a patient with multiple lost teeth and malocclusion (A), which had been more evident on the Rt side (upper row—left) due to sagittal palatal fracture, Le Fort I fracture, and mandibular fractures; Rt angle and Lt subcondylar intraoperative pictures following downfracture of Le Fort fracture with maxillary disimpaction, showing the palatal fracture. (B) Occlusal splint was applied and ideal occlusion was obtained using IMF screws (C). (Lower row—D) Postoperative frontal and oblique views 3 months postoperatively showing restoration of optimal occlusion. The lost teeth had been replaced by a temporary denture bridge to provide an aesthetic smile. **http://links.lww.com/PRSGO/B800**.) The patients' ages ranged from 18 to 52 years. Patients presented late (3–9 weeks post insult) due to serious neurological, ophthalmological, or orthopedics injuries that require previous intervention or ICU admission before being transferred to our department. All patients were followed up regularly for 6 months; however, one patient from the control grouped was missed during the follow-up period.

The time to obtaining optimal stable occlusion ranged between 80 and 120 minutes in the study group, with an average of 102.5 minutes. However, in the control group, the time ranged between 120 and 180 minutes, with an average of 150 minutes. There was a statistically significant shorter operation time till obtaining optimal occlusion between the two groups ($P < 0.0001$).

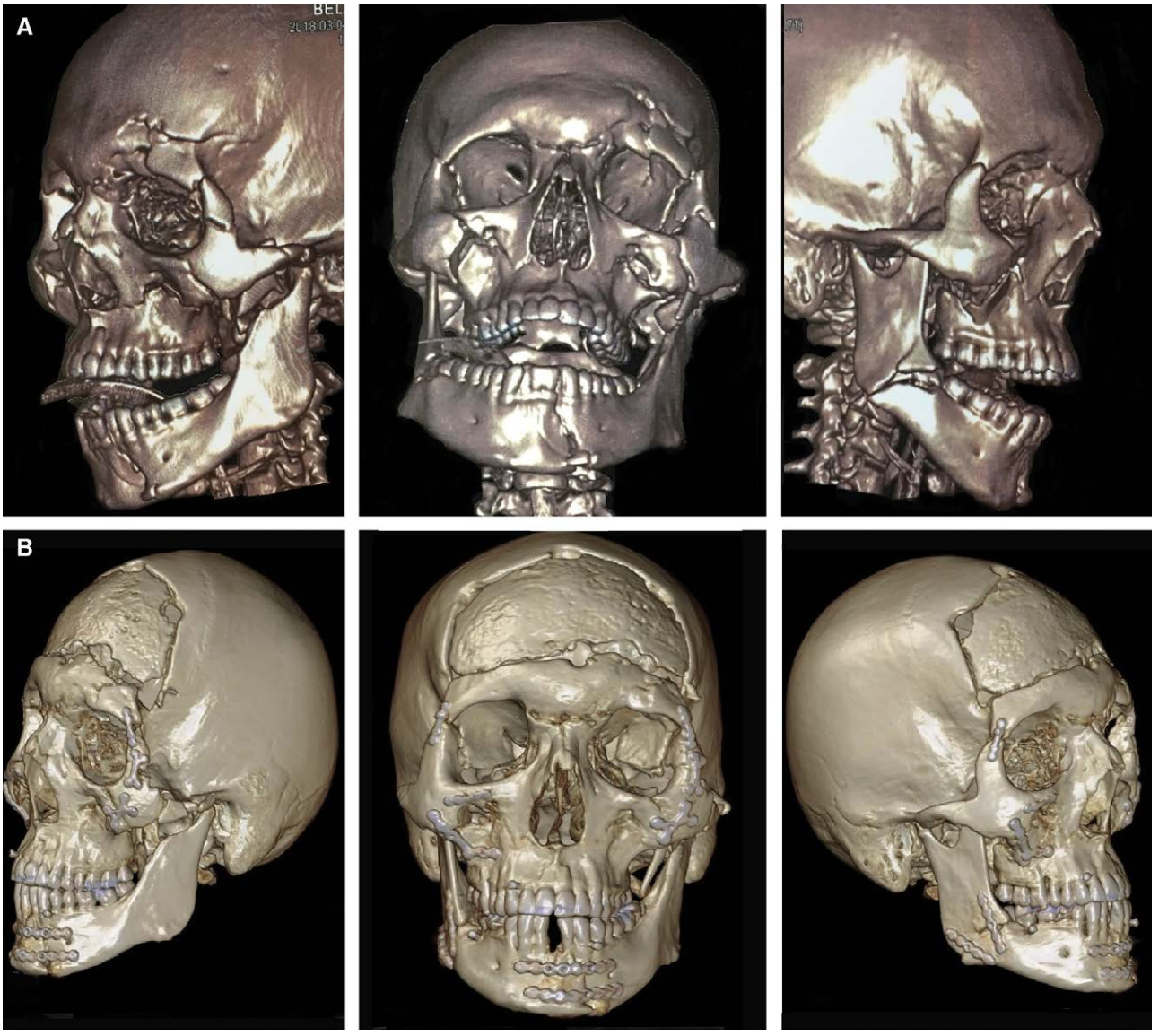

Fig. 4. Preoperative 3D-CT scans (A) of a 27-year-old male patient who had presented to our department with malunited facial fracture. (B) Nine weeks after the initial trauma (upper row). 3D-CT scans of the same patient after 6 weeks postoperatively with an optimal occlusion (lower row).

Table 1. Demographic Distribution of Patients in Both Groups in Relation to Associated Comorbidities

Variables	Measures	Splint Group (N = 10)	Control Group (N = 10)
Age (y)	Mean ± SD	33.2 ± 8.9	29.1 ± 7.0
	Range	19.0–52.0	18.0–46.0
Sex (n, %)	Men	9 (90%)	10 (100.0%)
	Women	1 (10%)	0 (0.0%)
Associated injuries (n, %)	Ophthalmological	3 (30.0%)	5 (50.0%)
	Orthopedic	3 (30.0%)	2 (20.0%)
	Neurological	4 (40.0%)	3 (30.0%)

Postoperative malocclusion was noticed to be less frequent in the splint group than in the control group: only one patient with residual malocclusion in the study group versus two patients in the control group. The patient with malocclusion in the splint group was believed to be technically related due to inadequate fixation rather than to the splint itself, unlike the other two patients in the control group who had been fixed adequately.

DISCUSSION

Delayed presentation of patients with pan-facial fracture is a bit common in daily practice. The mode of trauma which is usually high energy is often associated with multiple neurological or orthopedic injuries that necessitated early life-threatening intervention and patient stabilization before maxillofacial fixation.[7]

Carr and Mathog believed that bone healing beyond 3 weeks was in a "gray stage," where the edges of the fragment begin to absorb and remodel, which makes it very difficult to obtain anatomic reduction.[8] Hence, as a result of this delay, facial bone fractures often mal-unite, soft tissues shrink and contract, and scarring occurs, all of which make delayed treatment very difficult. This was unfavorable for achieving the primary goals of reconstruction, which included rapid bone healing and restoring both the function and the pre-injury 3D facial contours. Despite the major advances in maxillofacial surgeries and aggressive management, surgeons still experience postoperative deformities that continue to appear. Malocclusion was among repeatedly encountered deformities following surgeries,[9] and avoiding such unfavorable results was the main aim of our study.

Two classic approaches have been described for the management of pan-facial trauma; namely "bottom-up and inside out" or "top-down and outside in".[10–12] However, many authors reported that reconstruction of the occlusal segments in pan-facial fractures provided a lower template for subsequent 3D reconstruction of the fragile framework of the upper midface. In our study, we adopted the same principle for the management of our patients. Also, we agreed with those authors who advocated that the Le Fort I level of the maxilla needs to be restored in its width with mandibular–maxillary fixation. This mandibular–maxillary unit is then restored to its vertical height and position in relation to the skull base.[7,13,14]

He et al believed that the use of the mandible as a foundation to reconstruct delayed pan-facial fractures was reasonable because the mandible is the strongest facial bone and could be anatomically reduced more easily than the maxilla.[7] However, Pau et al reported a setback concerning this approach. Due to the presence of multiple fractures affecting the dental arches, along with loss of anatomical landmarks, which aid in guiding the start of reconstruction of the facial skeleton, re-establishment of the optimum occlusion through MMF was very difficult, and postoperative complications should be expected.[15]

Hendrickson and Manson previously proposed using the maxillary arch as a template for the mandibular arch: the maxillary arch should first be fixed posteriorly, at the level of the palatal vault, and then at the level of the pyriform aperture for the favor of providing proper facial width.[2,16] However, other authors suggested an alternative method to restore the occlusal plan by preparing an occlusal splint in acute fractures mimicking premorbid occlusion by segmenting post-traumatic casts of the maxillary and mandibular arches.[17] Tucker et al considered fracture stabilization with arch bars or external fixators along with the splints was often desirable when fractures were highly comminuted or the soft tissue envelope was compromised by tissue loss or burns.[18] Also, Morris and Tiwana mentioned that the occlusal splint was considered an excellent option for accurate reduction of the fractured maxillary segment.[19]

Accordingly, our study was conducted by applying the same principles of using preformed dental splints as mentioned previously, in order to assess the efficacy of these splints in restoring the occlusion as a primary step in the management of delayed presented pan-facial fractures. Intraoperatively, following fracture mobilization, segments were approached like puzzles. The splint provided a template into which all segments could fall. This restored the occlusal relationship between segments with less effort and helped achieve more stable reduction without the need for fixation of palatal fractures first if present. The mandibular-maxillary unit with splint in-between provided a very stable foundation, allowing the subsequent internal fixation of the fractures. The teeth were placed into their impressions on the splint as if the jaws were locked together, reducing the friction and instability, and preserving the occlusal relationship between them during the fixation of the fractures. This concept could overcome the drawbacks discussed by Pau et al concerning the multiple fractures disturbing the dental arches. Thus, the splint was found to be quite valuable in facilitating the reduction of these fractures.

Regarding patients who presented with malocclusion as a delayed complication, He et al utilized dental splints in restoring the occlusion following Le Fort I osteotomy for management of the delayed pan-facial fractures.[7] Yamamoto et al also adopted the same principles in the case of posttraumatic malocclusion secondary to condylar fractures in an elderly patient.[20]

It is worthy to report that one of the main advantages of these splints was the significant reduction of operative time: time from complete fractures exposure and dis-impaction till reaching the proper stable occlusion ($P < 0.0001$). Another parameter that we used for assessment in our study was the postoperative occlusion

status among patients. In the control group, two of the 10 patients had postoperative malocclusion with one patient lost during the follow-up. In contrast, in the splint group, one of the 10 patients still had postoperative malocclusion in the form of an anterior bite. However, this patient with the malocclusion in the splint group is believed to be technically related, resulting in rotation of the posterior maxilla on the one side and premature contact of second molars that made this anterior open bite occur. However, due to the small sample size, that might be a very primitive conclusion needing further investigation on a larger sample size.

Another advantage of such dental splints is the reliability in the management of comminuted palatal fractures, in which the width of the dental arch was difficult to restore. According to Pau et al, open repositioning and fixation of the palatal vault could be problematic in several ways. First, bending a miniplate so that it adheres passively to the concavity of the posterior palate could be difficult. Second, applying internal fixation to the palate could be challenging due to the oblique approach and the hindrance of the tongue. Third, mucosal incisions overlying the fracture were required to gain access to the palatal vault, but they increased the risk of late palate exposure.[15] Adding to that, the usual delay of treatment precludes providing the exact anatomical reduction and the sequent proper width and occlusion.

In our study, three patients with palatal fractures had been managed using the splint technique, whereas the other two patients had been treated without the splint. Despite there being no significant affection on the maxillary width or palatal curvature of these patients, the splint provided an easy way to restore the pre-injured maxillary width with less effort. Long-term follow-up of those patients revealed one patient in the splint group and one patient in the control group, who had a persistent small palatal fistula, which is considered a minor complication in contrast to the complications of palatal fixation.

In our study, the main limitations were the small sample size and relatively short follow-up time (only 6 months). Also, the discrepancy in fracture distributions and severity of fragmentation and comminution of bones were other limitations. Another point of weakness in our study was that most of our patients had comminuted fractures on either side of the jaw. Thus, we recommend further studies on a larger scale with a more uniform population and longer follow-up period, to be able to assess its significance in reducing postoperative malocclusion. We also believe that these splints would be of a greater value in patients with comminuted fractures of both maxilla and mandible.

CONCLUSIONS

Occlusal splints could be a good modality for restoring the pre-morbid occlusion in patients with delayed pan-facial fractures. This is a simple, reliable technique that could be easily integrated into our daily practice, and could help to decrease the intraoperative time needed for restoration of optimal occlusion and decrease the postoperative malocclusions.

Mohammed Ahmed Hussein, MD, PhD
Faculty of Medicine
Kasr Al-Ainy Cairo University
Cairo, Egypt
E-mail: mohammed.hussein@kasralainy.edu.eg

REFERENCES

1. Tullio A, Sesenna E. Role of surgical reduction of condylar fractures in the management of panfacial fractures. *Br J Oral Maxillofac Surg.* 2000;38:472–476.
2. Manson PN, Clark N, Robertson B, et al. Subunit principles in midface fractures: the importance of sagittal buttresses, soft-tissue reductions, and sequencing treatment of segmental fractures. *Plast Reconstr Surg.* 1999;103:1287–1307.
3. Follmar KE, Debruijn M, Baccarani A, et al. Concomitant injuries in patients with panfacial fractures. *J Trauma - Inj Infect Crit Care.* 2007;63:831–835.
4. Salvolini U. Traumatic injuries: imaging of facial injuries. *Eur Radiol* 2002;12:1253–1261.
5. Erdmann D, Follmar KE, Debruijn M, et al. A retrospective analysis of facial fracture etiologies. *Ann Plast Surg.* 2008;60:398–403.
6. Ellis E, Throckmorton GS. Bite forces after open or closed treatment of mandibular condylar process fractures. *J Oral Maxillofac Surg.* 2001;59:389–395.
7. He D, Zhang Y, Ellis E. Panfacial fractures: analysis of 33 cases treated late. *J Oral Maxillofac Surg.* 2007;65:2459–2465.
8. Carr RM, Mathog RH. Early and delayed repair of orbitozygomatic complex fractures. *J Oral Maxillofac Surg.* 1997;55:253–258.
9. de Matos FP, Arnez MFM, Sverzut CE, et al. A retrospective study of mandibular fracture in a 40-month period. *Int J Oral Maxillofac Surg.* 2010;39:10–15.
10. Wang L, Lee TS, Wang W, et al. Surgical management of panfacial fractures. *Facial Plast Surg.* 2019;35:565–577.
11. Buchman SR, Cavaliere CM. Management of panfacial fractures. In Weinzweig J (ed): *Plastic Surgery Secrets.* Philadelphia: Mosby Elseveir; 2010:326–329.
12. Curtis W, Horswell BB. Panfacial fractures: an approach to management. *Oral Maxillofac Surg Clin North Am.* 2013;25:649–660.
13. Li Z, Yang R, Zhang C, et al. Why should we start from mandibular fractures in the treatment of panfacial fractures? *J Oral Maxillofac Surg.* 2012;70:1386–1392.
14. Ali K, Lettieri SC. Management of panfacial fracture. *Semin Plast Surg.* 2017;31:108–117.
15. Pau M, Reinbacher KE, Feichtinger M, et al. The mandibular symphysis as a starting point for the occlusal-level reconstruction of panfacial fractures with bicondylar fractures and interruption of the maxillary and mandibular arches: report of two cases. *J Cranio-Maxillofacial Surg.* 2014;42:e51–e56.
16. Hendrickson M, Clark N, Manson PN, et al. Palatal fractures: classification, patterns, and treatment with rigid internal fixation. *Plast Reconstr Surg.* 1998;101:319–332.
17. Konas E, Tunçbilek G, Kayikçioglu A, et al. Splint-assisted reduction of comminuted or complex maxillofacial fractures. *J Craniofac Surg.* 2011;22:1471–1475.
18. Tucker DI, Zachar MR, Chan RK, et al. Characterization and management of mandibular fractures: lessons learned from Iraq and Afghanistan. *Atlas Oral Maxillofac Surg Clin North Am.* 2013;21:61–68.
19. Morris CD, Tiwana PS. Diagnosis and treatment of midface fractures. In Fonseca RJ, Barber HX, Powers MP (eds): *Oral and Maxillofacial Trauma.* St. Louis, MO: Elsevier Saunders; 2013:416–450.
20. Yamamoto S, Takenobu T, Kouchi I, et al. Application of Le Fort I osteotomy for post-traumatic malocclusion secondary to condylar fractures in an elderly patient: a case report. *J Clin Diagnostic Res.* 2018;12:ZD04–ZD06.