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UTILIZATION OF VIRTUAL SURGICAL PLANNING FOR SURGICAL SPLINT-ASSISTED MANDIBULAR FRACTURE REDUCTION

Mohamed Mahmoud Abo-El Fetoh Elshorbagy[1*], Mohamed Abd El-Akher Mohamed[2], Samy Saeed El Naas[3]

ABSTRACT

Objectives: The current study utilized virtual surgical planning for surgical splint-assisted mandibular fracture reduction and fixation by miniplates and screw in comparison to conventional Erich arch bar application. **Subjects and methods:** twelve patients having parasymphyseal or body fractures were included in the study. Their ages ranged between 20 and 43 years. Patients were randomly divided into two equal groups; **Study group** (n=6): mandibular fracture reduction was achieved by virtual surgical planning for lingual splint fabrication and application. **Control group** (n=6): mandibular fracture reduction was achieved by Erich arch bar. The patients were clinically and radiographically evaluated through assessing operation time, occlusion by T scan and bone density. **Results:** The operating time of the study group 20.67 ± 5.05 min was statistically significantly lower than in the control group 48.5±7.94 min. The occlusion improvement of the study group was significantly better than control group after both 1 week and 3 months. There was significant increase of bone density after 3 months in both groups. **Conclusions:** Virtual surgical planning for surgical splint (VSPSS) simplifies the reduction and fixation of mandibular fractures, especially those which are displaced lingual, decrease operating time and improve fracture stability.

KEYWORDS: Virtual surgical planning, lingual splint, Erich arch bar, Mandibular fracture.

INTRODUCTION

The greatest and most noticeable bone in the maxillofacial area is the mandible. These anatomical features explain why face fractures frequently affect the mandible[(1)]. Traditionally, closed reduction was thought to be the best course of action for treating this fracture[(2)]. The main goals of successfully treating mandibular fractures are the proper reduction of the fracture segments, fracture stabilization with achievement of proper occlusion and immobilization. Elimination of infection, malunion, soft tissue destruction is also of a paramount importance [(3)].

The incapacity to confirm fracture reduction on the lingual side intraoperatively and the challenge of precisely reducing the anatomic displacement of the displaced lingual cortical plate to the buccal cortical plate[(4)]. When treating jaw fractures, surgical splints are made to create the ideal preinjury occlusion. These splints serve as stability throughout the period of bone healing, help with the anatomical reduction of bony segments, and immobilize and preserve

1. Masters Candidate, Dentist at Ministry of Defense
2. Professor, Department of Oral and Maxillofacial Surgery, Faculty of Dental Medicine, Boys, Cairo, Al-Azhar University
3. Lecturer, Department of Oral and Maxillofacial Surgery, Faculty of Dental Medicine, Boys, Cairo, Al-Azhar University

• ***Corresponding author*:** mm7511828@gmail.com

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the reduction before to or during the application of maxillomandibular fixation (MMF)[5,6].

The world's most widely used standard for medical imaging information is called Digital Imaging and Communications in Medicine (DICOM). Technological advances in medical and imaging engineering, as well as the development and falling prices of hardware and software, have made three-dimensional (3D) printing from DICOM pictures simpler. Surgical planning, surgical simulation, and teaching are just a few of the oral and maxillofacial surgery scenarios that increasingly make use of patient-specific 3D models[7, 8].

A thin, flexible bite transducer that is sensitive to pressure is integrated into a recording sensor that is fashioned like a dental arch to record and analyze tooth contact, force, and timing in real-time using the T-Scan digital occlusion analysis system[9].

This study evaluated the use of virtual surgical planning for surgical splint (VSPSS) fabrication in treatment of mandibular fractures and restoring ideal pretrauma situation.

PATIENTS AND METHODS

Study design: It is a randomized controlled prospective clinical study.

Study setting and population: 750/238

The study included 12 patients (10 males and 2 females) aged between 21 and 43 years. Patients were selected from those attending to the Emergency Unit of Sayed Galal Hospital, Al-Azhar University, Cairo, Egypt and Kobri Al Kobba Military Hospital.

Eligibility criteria:

Inclusion criteria:

Patients with parasymphyseal or body mandibular fracture who are indicated for open reduction and internal fixation. The inclusion criteria for this study included patients age 21 to 43 years with no gender differences.

Exclusion criteria: Patients with angle, ramus and condylar fracture. Patients with concomitant maxillary fracture. Patients with malunion fracture. Patients with gunshot injury or soft tissue loss. Patients with comminuted fracture. Infected mandibular fracture. Fracture edentulous patient.

Preoperative clinical evaluation: Patients who were recommended for open reduction and internal fixation (ORIF) after presenting to our department with a mandibular fracture. demographic information about every patient, including age, gender, and pertinent medical history. examination for ecchymosis, hematoma, and lacerations. Actions taken were recorded. Written informed permission was acquired from every patient who took part in the research.

Radiographic evaluation:

Computed tomography (CT) was taken to define the location, type and number of fracture, presence of tooth in fracture line, displacement of fracture segments, DICOM files were used for digital designing and fabrication of the lingual splint.

Methods:

Data Acquisition and Presurgical Planning.

CT images show the patient's craniofacial region, with a slice thickness of 1 mm. Using Digital Imaging and Communication in Medicine (DICOM), the pictures were processed into a data file. Utilizing 3matic for virtual bone reduction and mimics for bone segmentation, the formats were transformed into stereolithographic (STL) pictures. The design of the splint holes in VSP included their shape, thickness, and placement. For improved recall and adaptability, the (VSPSS) outline was placed above the contour's height. A biocompatible resin was used to build the final planned product (VSPSS) after the data was exported as an STL file to a 3D printer. Putting the surgical splint's finishing touches. Surgical splints are cold-sterilized.

Intervention

ORIF of all fractures was carried out using a standard surgical protocol, by a single surgeon. Vestibular incision was applied as required by the fracture pattern. Mucoperiosteal flap reflection was carried out to expose and visualize the fractured segments. Hemostasis was properly achieved and the surgical field irrigated.

Reduction of fracture:

A. study group

The (VSPSS) outline was above the height of contour of the teeth to prevent occlusal interferences. The 1.5-mm diameter holes were made at interdental area for passing interdental wires. Then, the surgical splint was fixed by three ivy loop; right, left and anterior. The thickness of the surgical splint was 2 to 3 mm for maintaining adequate strength. Intermaxillary fixation was done in the maximum inercuspation in order to maintain occlusion during adaptation and fixation of the miniplates. (Figure. 1)

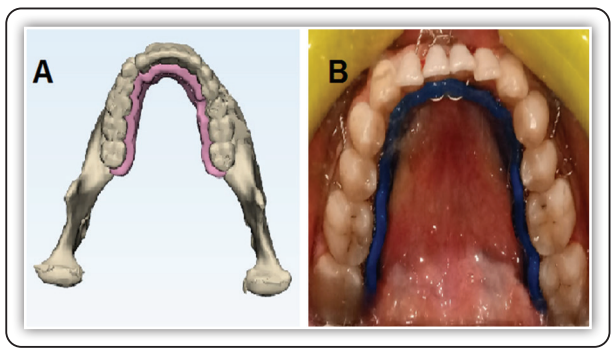

FIG (1) Virtual and clinical application of VSPSS (A) Virtual surgical planning for surgical splint. (B) VSPSS fixed clinically in place.

B. Control group: By Eric arch bar

Mandibular miniplates and screws were selected and adapted to fixation the fracture:

Once the redaction of the fracture and the maximum intercuspation of teeth were assured, two plates were cut 2.0 mm miniplates. Passively adapted and fixed to inferior and superior borders of the outer surface of the mandible respectively with screws. After tightening of the screws, the occlusion was rechecked again. Any bleeding point was controlled then the wound was thoroughly debrided, irrigated with warm saline solution and sutured back in layers with 3-0 polyglycolic resorbable sutures material. The underlying muscles were firmly reattached to its origin to prevent ptosis of the lip and chin and the overlying mucosa was then closed in a running suture manner. Recording the operative time from the beginning of the (VSPSS) or arch bar fixation until first miniplates adaptation. Recording the state of occlusion after one week and three months by T scan. Evaluation bone density at the fracture lines after one week and three months by Cone beam computed tomography (CBCT).

RESULT

Subjects of the present study comprised 12 patients, both groups 5 male (83.3%) and 1 female (16.6%). Patients of the study group ranged in age between 22 to 32 years with a mean age of 26.33±3.77 years. Control group 21 to 43 years with a mean age of 30.00±0.84 years. There was no statistically significant difference according to age between both groups.

All patients have completed the study throughout the planned observation periods. Healing was uneventful. All fracture showed complete bone healing without complication requiring further treatment or hospitalization.

1. **The intraoperative time** study group mean values 20.67±5.05 minutes. Control group mean values 48.5±7.94 minutes. The difference in operating time duration between both groups was statistically significant.
2. **The status of occlusion** of the study group after 1-week mean values 19.03±7.76% and after 3 months mean values 3.40±2.12%. The results were statically significant. Control group after 1 week mean values 40.50±3.18% and after

3 months mean values 11.27±8.13%. The results were statically significant. There was significant improvement of occlusion after 3 months in both groups. The occlusion improvement of the study group was significantly better than control group after both 1 week and 3 months (Table 1).

TABLE (1) Paired student "t" test comparing mean values and standard deviation of occlusion improvement after 1 week and 3 months in each group and independent student "t" test comparing occlusion improvement of both groups after 1 week and after 3 months.

Occlusion	1 Week	3 Months	"t"	Probability
	Mean ± SD	Mean ± SD		
Control	40.50 ±3.18	11.27 ±8.13	3.179	0.012*
Study	19.03 ± 7.76	3.40 ± 2.12	4.123	0.005*
"t"	2.241	2.294		
Probability	0.024*	0.022*		

3. **The Bone density** of the Study group after one-week mean values 215.18±40.92 and after 3 months mean values 397.97±63.71. The results were statically significant. Control group after one-week mean values 191.05±45.25and after 3 months mean values 336.95±54.73. The results were statically significant. There was no significant difference between two groups after 1 week and after 3 months. There was significant increase of bone density after 3 months in both groups.

DISCUSSION

Soft tissue, teeth, and bone structures of the maxillofacial region are frequently injured in face trauma. Between 40% and 62% of traumas result in mandibular fractures, which are the most frequent maxillofacial injuries. Using miniplates and screws, open reduction with internal fixation and maxillomandibular fixation (MMF) are two examples of dental circumferential wiring procedures[10-12]. Have been the standard reduction techniques for a long time. A successful, stable, and accurate reduction depends on restoring the teeth's proper occlusion[13]. Throughout mandibular fixation, these splints help to preserve and aid in the anatomical reduction of bone segments by immobilizing them[14].

In the present study, 12 patients having parasymphyseal and body fractures were randomly assigned into two equal groups;

Study group**:** treated by virtual surgical planning for surgical splint intermaxillary fixation (IMF) for fracture reduction and fixed by miniplates and screws.

Control group**:** treated by intermaxillary fixation (IMF) using Erich arch bar for fracture reduction and fixed by miniplates and screws.

The current state of preoperative planning has been altered by developments in digital technology, computer-aided design and manufacturing (CAD/CAM), and diagnostic imaging. VSP has given oral and maxillofacial surgeons a more prominent role in enhancing treatment results[15-17].

The whole surgical operation, including the first wire around the arch bar or surgical splint, the reduction of the fractured segments to their normal position, the IMF upper and lower, and the installation of the first screw in the plate, was recorded throughout the surgery.

The average operating time mean values required for study group was 20.67±5.05 min. and that of Control group was mean 48.5±7.94 min. The operating time of the study group was statistically significantly lower than in the control group. This findings can be attributed to the ease us fabrication of the virtual surgical planning for lingual splint where it uses the segmentation software mimics for bone segmentation and 3maticfor virtual reduction

of bone, occlusion and splint designing outside the patient mouth to verify fracture reduction on the lingual side intraoperative, while the conventional intermaxillary fixation (IMF) by Erich arch bar needs more time to check the adaptation of the arch bar and wire to maintain good reduction and occlusion inside the patient's mouth especially from the lingual side which was in agreement with Wichuda Kongsong et, al[18]. They came to the conclusion that surgeons could treat maxilla mandibular fractures more effectively, with less operating time and better fracture stability, if they used VSPSS.

By biting down on a small sensor, the T-Scan is a straightforward digital occlusion study for assessing patient bite. The program then records tooth contact and force in real-time. This quick assessment provides complete transparency on the location of the bite's junction and its role in causing dental problems[19].

In the present study the status of mean values of occlusion of the study group after 1weekwas19.03±7.76 and after 3 months, mean values was 3.40±2.12. The results were statically significant. For Control group after 1 week mean values was40.50±3.18 and after 3 months mean values 11.27±8.13. The results were statically significant. The difference between study group and control group values was statistically significant. Post-operative evaluation after one week and three months revealed that all of the cases had normal occlusion.

Results of the current study was in accordance with WichudaKongsong et,al[18]. All patients had stable and repeatable occlusion. Fractures when managed by closed method. T-Scan could detect significant changes in the occlusion even at the third-and sixth- month evaluations.

In the present study, CBCT was also used to evaluate bone density, which is an important factor that reflects the bone quality after bone reduction and fixation. Razi et, al[20]. Study showed a strong correlation between HU in CT scans and the voxel gray scale in CBCT and suggested that the voxel value in CBCT can be used for the estimation of bone density.

The bone density mean values of the Study group after one-week was 215.18±40.92 and after 3 months was 397.97±63.71. The results were statically significant, because fracture line after one-week was dark line with low-grade bone density values and after 3 months bone healing increased bone density. For the Control group after one-week mean values was 191.05±45.25 and after 3 months mean values was 336.95±54.73. The results were statically significant. The bone density values for both groups after 3 months complete heling and no deferent.

Finally, VSPSS boundary designs may resemble denture designs. Surgeons should use the more straightforward placement of the passing wire hole. A 1.5-mm-diameter hole should be drilled in the interdental region in a horizontal direction for the application of circumdental wire. The surgeon's ability to pass a wire from the buccal or lingual directions would be much easier as a result.

CONCLUSION

Particularly for mandibular fractures that are displaced lingually, VSPSS splints make the reduction and fixing process easier. Arch bars, plates, and screws can be applied before or during the shattered segments are held stable by the VSPSS, which also prevents rotation and distraction. In the context of virtual surgical planning and simulation (VSPSS) fabrication, the displaced and broken bone segments are digitally manipulated and aligned to a suitable anatomic closure. Realigning and securely stabilizing dentoalveolar segments, as well as uniting all of the teeth into one, are made possible by VSPSS. Patients with sufficient or inadequate dentition benefit from the reduction and/or fixation provided by VSPSS.

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