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COMPUTER ASSISTED SURGERY VERSUS CONVENTIONAL FREE HAND TECHNIQUE IN MANDIBULAR RESECTION AND RECONSTRUCTION

Hesham Fattouh Abdallah*

ABSTRACT

Aim: The purpose of this study was to compare the outcomes of the computer assisted surgery with conventional free hand technique in mandibular resection and reconstruction regarding esthetics, function and the consumed time.

Methods: 8 patients who underwent mandibular resection and reconstruction were categorized according to the resection and the reconstructive technique: in the computer assisted surgery group, cutting guides and prebent reconstruction plates were used in resection and reconstruction while the conventional control group underwent traditional freehand osteotomies and intraoperative plate bending. A comparison was made between the 2 groups regarding demographic data, perioperative and postoperative outcomes.

Results: All patients achieved successful mandibular reconstruction procedures regarding both function and esthetics, the mean operation time and hospital stay postoperatively was reduced in the computer assisted surgery group, but the difference between the 2 groups was insignificant.

Conclusion: Computer assisted resection and reconstruction of the mandible has a significant value regarding the simplicity and predictability of the surgery in the operating room, however it has no functional superiority compared to the free hand method, so the combination of virtual planning with guided surgery should be weighted specifically for each case based on the cost-benefits value.

KEYWORDS: Mandibular resection, Computer assisted surgery, mandibular reconstruction, Virtual surgical planning

* Associate Professor, Oral and Maxillofacial Surgery Department, Faculty of Oral and Dental Medicine, Cairo University

INTRODUCTION

Mandibular defects after removal of a lesion can greatly affect quality of life, it impacts facial aesthetics as well as speech, swallowing and breathing leading to severe aesthetic and functional deficits [1-2], functional and aesthetic restoration is challenging as resection is usually complex resulting in multiple mandibular segments [3]. Mandibular reconstruction aims to regain the capability of the patient to speak and eat properly and also to preserve an accessible airway, to achieve these reconstructive goals, a great level of surgical precision is required. [2]

Before the development of computer-assisted surgery (CAS), the traditional way for mandibular resection and reconstruction relied on segmental osteotomies performed by freehand and then fixed using a reconstructive plate bent intraoperatively by hand and the results greatly varied between surgeons according to their technical skill and experience [4]. In recent years, cutting guides and other computer tools such as stereolithographic model printing had significantly simplified mandibular reconstruction [5].

Since its introduction by Hirsch in 2009, computer-assisted surgery, often referred to as rapid prototyping or computer-aided design and computer-aided manufacturing (CAD/CAM) for mandibular reconstruction had been increasingly [6]. The procedure of CAS in mandibular reconstruction entails various phases: planning, modelling and surgical[7], it leads to high degrees of precision and acceleration of a time-consuming step in the operating room[8]. In the planning phase, Digital Imaging and Communications in Medicine (DICOM) files are created from a computed tomography (CT) scan of the craniofacial skeleton, and 3D models of the virtual planned components are created in the modeling phase [9].

CAS offers planning osteotomies for resection, mirroring the unaffected mandible, creating surgical resection guides, fabricating patient-specific reconstruction plates together with evaluating the bone plate relationships for the best orientation of dental implants, and most crucial, regain the proper occlusion [9-10]. Further reported advantages are minimized intraoperation time together with enhanced opportunities in teaching younger surgeons to participate in the work up planning and manufacturing sessions [11]. Finally, preoperative planning enables precise dental implant placing for oral rehabilitation in a shorter time, as it permits putting dental implants in a very accurate position with a satisfactory result [12].

On the other hand, using CAS increases both the preoperative planning time and associated costs. Additionally, challenging to implement intraoperative adaption to changes that might happen in the extent of resection or reconstruction in virtually planned cases [13].

The objective of this study was to assess and compare the functional outcomes in term of function, accurate contouring of reconstruction Plates, aesthetics and surgical time in patients undergoing mandibular resection and reconstruction done in two techniques: traditional freehand and computer-aided surgery using stereolithographic model and cutting guides.

MATERIALS AND METHODS

This study was conducted in Oral and Maxillofacial surgery department, Faculty of Dentistry, Cairo University on 8 patients who underwent mandibular resection and reconstruction with a 2.7 mm reconstruction plate. The study included 8 patients (7 males and 1 female) suffering from a disease that necessitates mandibular resection and reconstruction, patient's mean age was 51 years, patients were randomly classified into 2 groups according to the intended treatment plan:

Group A: included 4 male patients, the surgery was done by the aid of computer programmes (computer assisted surgery). **Group B**: included 4 patients; 3 males and 1 female, patients of this group were managed by freehand technique utilizing surgeon's skills only. Exclusion criteria were patients with a lesion involving the condylar process or crossing the midline preventing the use of the normal side as a mirror image for the affected one, a detailed informed written consent was obtained from all patients including all the surgery details and the possible complications.

Clinical examination of the patients included assessment of the occlusion and related teeth, intraoral cortical expansion, facial asymmetry, maximum incisal opening and temporomandibular joint disorders. Preoperative craniofacial CT with 0.5 mm fine cuts was done for all patients to obtain three dimensional (3D) models of the craniofacial skeleton, all procedures were performed by the same surgical team, patients were categorized according to the reconstructive technique, either computer assisted surgery or conventional free hand.

Group A: computer assisted surgery (CAS):

CT DICOM files were imported into specialised surgical planning software (Mimics 21.0, Materialise HQ, Leuven, Belgium) where a thresholding process was done to eliminate soft tissues and to further segment the mandible alone. The segmental resection was simulated on the software and a series of points were put on the 3D mandibular model along the inferior boundary, the posterior and anterior resection margins to acquire the surgical guide design that will be used in mandibular osteotomy. The original mandibular outlines were then restored using a mirror-image of the unaffected side in the sagittal plan, which was afterwards used as a template to preoperatively bend a reconstruction plate. After importing mandibular bone from DICOM files to STL format (Standard Tessellation Language), the new mandible together with virtual cutting surgical guides were 3D printed into a stereolythographic mandibular model and cutting guides by a fused deposition modelling machine (Ling Tong III, Beijing SHINO, Beijing, China) (Figures 1a - 1b – 1c). After printing and before use, both the model and the guides were manually washed by ultrasonography process and then sterilised chemically in glutaraldehyde solution 2% (Cidex, Johnson & Johnson Co. NJ, USA) for 12 hours

Performing surgery:

After mandibular exposure, the sterilized cutting guides were temporarily fixed with 10-mm monocortical screws to the mandible (Figure 2a). mandibular osteotomies were performed by surgical saw along the guide's flange directed by the cutting slots, mimicking the virtually planned mandibular osteotomies, the guide was then removed, and the bony segments were connected using a 2.7 mm reconstruction titanium plate that was prebent on the same digitally planned model, precisely matching the contour of the native jaw (Figure 2b).

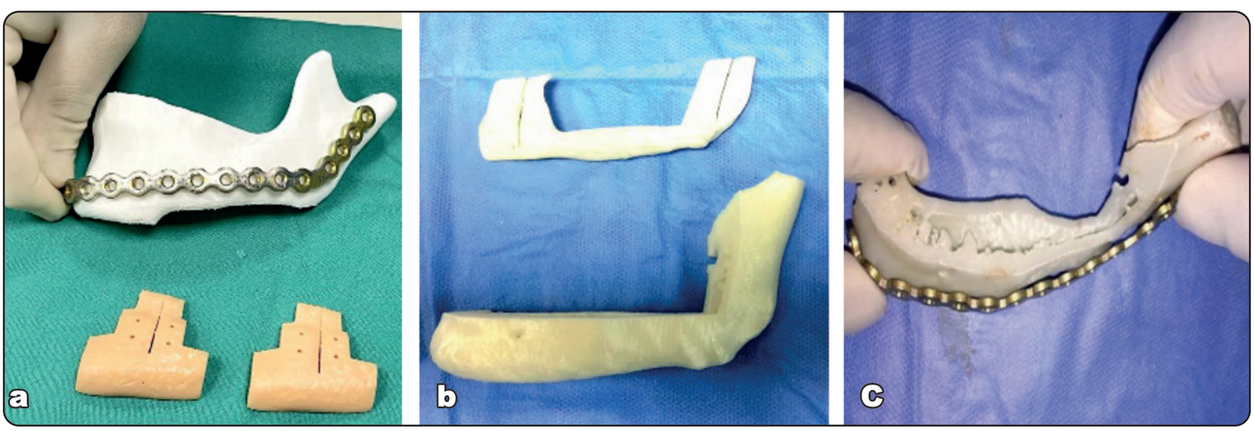

Fig. (1) a): Printing the stereolythographic mandible & surgical guides. b): Virtual surgery done on the model. c): Reconstruction plate prebending after virtual surgery

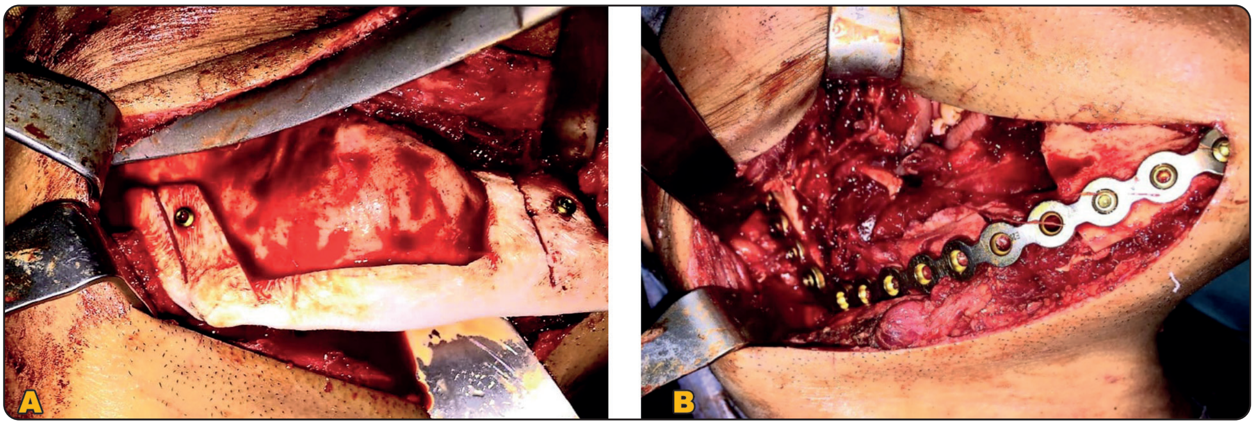

Fig. 2 (a): Cutting guides temporary fixed intraoperatively (b): Prebent reconstruction plate fixed intraoperatively

Group B (Free hand group):

All surgical procedures including the mandibular osteotomies and bending the reconstruction plate were done intraoperatively using a freehand technique without any computer aids preoperatively.

Outcomes:

All demographic data including patient's age, sex and comorbidities were documented, All intraoperative data were recorded and evaluated, including total operative time from skin incision to closure, patients were observed post-surgical both radiographically by CT (an immediate postoperative CT scan with the same preoperative protocol) (Figure 3), computed tomographic image overlay to be superimposed onto the preoperative one recording technical accuracy and clinically including aesthetic contour, functional outcomes, length of stay in hospital, uneventful healing, infection and any other complication was recorded.

Statistical analysis was done comparing patient demographics, intraoperative factors, and outcomes between conventional and CAS groups. Contingency data are shown as percentages, whereas continuous data are presented as means with standard of deviations or medians with interquartile ranges. The Mann-Whitney *U* test was used for comparison of median values. A value of $p < 0.05$ was considered significant. Statistical software was employed for analysis (IBM SPSS for Mac, Version 19.0; IBM Corp., Armonk, N.Y.).

Fig. (3): Postoperative CT taken with the same parameters as the preoperative ones.

RESULTS

8 patients categorized into 2 groups underwent mandibular resection and reconstruction, there were no significant inter-group differences regarding demographic data: 4 male patients underwent CAS using the CAD/CAM and 3d printing technology; with a mean age of 51.9 ± 14.7 years and the cause of resection was 2 patients with ameloblastoma, 1 with odotogenic keratocyst and 1 osteoradionecrosis case, regarding the free hand group; there were 3 male patients and 1 female, the average age was 54± 12.7 years and the cause of resection was 1 patient with radicular cyst, 2 with benign tumors, and 1 case of osteoradionecrosis.

The mean operation time was reduced in the CAS group, despite the fact that the use of cutting guides in mandibular osteotomies precluded the need for intraoperative measurement and real-time navigation, but the difference in the operation time between the two groups was not significant, taking in consideration that there was extra time used in CAS virtual planning: with a mean average about 3 hours, and additional one hour and half for printing. Mean operation time for the conventional versus CAS group was 272.29 minutes versus 265.63 minutes respectively, also the mean hospital stay postoperatively was reduced in the CAS group; the mean hospital stays for the conventional versus CAS group was 2.93 days versus 2.15 days, however the difference between the 2 groups was insignificant.

All patients achieved successful mandibular reconstruction procedures with the preoperative occlusion and a symmetric mandibular contour on 3D CT study and clinical examination. No patients required significant modification of the intended mandibular bone resection during surgery compared to the pre-planned 3D simulation in the CAS group.

The accuracy of the reconstructed contour was assured by image superimposition with the native mandible and the virtual one revealing a more precious outcome between the digitally planned 3D models and the results of the surgery compared to the freehand technique. These results indicate that the mandibular contour symmetry was significantly improved in the CAS group compared with the conventional group. In the CAS group, the accuracy assessment revealed a mean distance deviation of 2.7 ± 1.4 mm for mandibular osteotomies in the CAS group than the preoperatively planned.

No huge complications such as infection or allergy were observed during or after the surgery in both groups. There were no significant inter-group differences in postoperative course.

DISCUSSION

The CAD / CAM technology enables the surgeon to virtually define the bone segment to be resected and preciously prebend the reconstruction plate on the steriolithographic model. The advantages of virtual planning in maxillofacial resection and reconstruction have been well documented: improved surgeon comfort, decreased surgery time and improved aesthetic and functional outcomes [14-15-16]. However, although preoperative virtual planning and guided resection, together with reconstruction using prebent reconstruction plate, have greatly facilitated the challenging 3D reconstruction process of the mandible and simplified the production of cutting guides in the last few years, there is a continuing debate whether CAS is better than traditional freehand surgery in relation to clinical results.

Like what we concluded, Kozakiewicz et al. proved that CAD/CAM based virtual planning could be used in many reconstructive surgical procedures with better results and repeatability of surgical procedure regarding both mandibular resection and restoration [17], also Hanasono and Skoracki reported that resection with virtually simulated methods showed significant improvements in the accuracy in comparison to the conventional freehand group [18]. Ayoub et al. similarly found a deviation of 6 mm using conventional methods, which was significantly improved to 1.5 mm in the computer-assisted group in mandibular resection and reconstruction cases [19].

Although Tarsitano et al. and Sieira et al. proved that both the pre- and intraoperative workflow had decreased the time of operation and the hospital stay [(20-21)] , in our study, we concluded that the shortened surgery time in the CAS group was not statistically significant when compared to the freehand group, probably due to the presence of too many parameters apart from the use of cutting guides and prebending of the plate impact surgery time, moreover there was a preoperative planning and printing time in the CAS group which was not spent in the conventional group.

In the literature, reports show great contradictory concerning the accuracy, and thus the absolute benefit of virtual planning compared to traditional freehand method, as we concluded from our study, the researches done by Stirling Craig and Zheng demonstrated improved accuracy in terms of angular deviation and inter-segment gap when using mandibular resection cutting guides [(4- 22)]. While Bouchet et al. assessed esthetic and functional outcome with CAD/CAM compared to the conventional freehand approach and reported similar results between the two groups regarding mandibular protrusion, mouth opening and patient satisfaction [(23)], also De Maesschalck et al. reported a comparable symmetry between the two techniques [(24)]. However, most of these studies used small cohorts, comparing virtual planning to post-operative outcomes, which may not accurately reflect actual status.

CONCLUSION

Our preliminary experience regarding the CAS technology in the workflow of mandibular resection with cutting guides together with reconstruction using prebent plates on 3D modelling had greatly simplified the surgery compared to conventional freehand osteotomy, improved comfort during surgery with more predictable outcomes, however, considering the high significant cost of CAD and CAM, it appears to be very challenging to assess the real added value of these digital tools regarding the cost-to-benefit equation.

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