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THE IMPACT OF COMPUTER-AIDED DESIGN AND MANUFACTURING ON THE TIME REQUIRED FOR CORTICAL LAMINA HARVESTING AND POSITIONING FOR AUGMENTATION OF ATROPHIC RIDGES (RANDOMIZED CLINICAL TRIALS)

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ABSTRACT

Background: When considering computed tomography and the advancement of planning software, it is clear that the digital era has fused with maxillofacial surgery, and computer-aided technology is playing a crucial role in treatment planning to get the best possible outcome with safety and precision. Bone augmentation using autogenous cortical lamina technique is a long procedure, so this study intended to evaluate the duration of surgery operation using a printed case-specific polymer guide VS the conventional technique.

Patient and methods: A total of fourteen cases participated in this investigation, seven patients with narrow ridges (control group) cortical lamina from the chin area were harvested and fixed by hand on, whereas the rest of the cases underwent the same operation utilizing computer-aided two case-specific guides(for lamina harvesting and second guide for positioning).

Results: The mean operation duration (min.) in the intervention group was (149.57±27.26), in comparison to (153.86±32.15) in the control group, with no significant difference between groups (p=0.793)

Conclusion: This study demonstrated the effectiveness of computer-assisted bone grafting for augmenting atrophic ridges however, with insignificant effect on the operation time.

KEYWORDS: Cortical lamina, Operation duration, Computer-aided designing, Computer-aided manufacturing

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INTRODUCTION

Variable treatment planning is possible for the proposed implant site in cases with horizontal alveolar bone defects, according to the remaining alveolar bone if there is insufficient spongy bone surrounded by cortical bone for a narrow implant, ridge splitting, spreading, or even distraction osteogenesis cortical lamina technique using autogenous bone considered as one of the reliable augmentation techniques in this situations[1,2].

The cortical lamina grafting is a technique of using a thin bone plate to resemble a shell acting like a biological membrane anchorage to the resorbed ridge using monocortical screws creating a box-like gap to be filled with bone particles this technique,

Khoury demonstrates this technique and concludes that this procedure offers significant osteogenic capacity made by stable and thin cortical shell allowing for high revascularization and filled with autogenous bone particles carrying osteoprogenitor cells[3].

However, this technique has some drawbacks, including donor site morbidity, a lengthy preparation period and operation time, and it is a sophisticated procedure that requires a high learning curve[4].

Clinical professionals and surgeons may now perform delicate interventions with high levels of precision and fewer risks of complications due to the development of modern digital imaging techniques such as computer tomography (CT), Cone beam computerized tomography (CBCT), and ultrasound for enhancing visualization of the patient's anatomy and the evolution of CAD/CAM technology[5,6].

Computer-aided design and manufacturing technology have gained popularity as a technique for the creation and production of unique spatial models with computer assistance. These models can then be utilized for preoperative planning, education, and surgical simulation purposes, such as the creation of specially dimension-fitting implants, surgical templates , contoured bone blocks, shells, or membranes in various materials for guided bone regeneration[7].

Prolonged operation duration is directly linked with surgical complications such as increased blood volume loss, prolonged graft ischemic duration, and the demands for high doses and concentrations of local anesthetic drugs with vasoconstrictors to accommodate surgical duration with the risk of overdose toxicity especially for patients with liver or kidney problems that may compromise drug metabolism[8]. These clinical characteristics are influenced by the complexity of the operation and the surgeon's expertise. Therefore, a lengthy procedure and significant complications may be related to highly invasive surgery and poor surgical technique[9].

This study aimed to use computer technology to make a long-complicated procedure faster and simpler for inadequately trained surgeons.

PATIENT AND METHODS

A total of 14 patients were included in this investigation, randomly selected from the department of Oral and Maxillofacial surgery's outpatient clinic at Future University hospital. All patients in the study read and signed the informed agreement-consent form, which followed the Declaration of Helsinki's rules for human testing. The research was approved ethically by the ethics committee of Future university in Egypt.

The patients were selected based on the following inclusion and exclusion standards:

Inclusion criteria

Adult patients seeking implant placement having severely deficient alveolar ridge in aesthetic zone with no bone width allowed for ridge splitting between the ages of 22 and 45, and willing for the procedure and follow up visits.

Exclusion criteria:

Patients with any systemic or medical condition that may interfere with wound healing, smokers, cases with active pathosis, and patients with poor oral hygiene.

Randomization: using internet software (http://randomizer.org), cases were randomly divided into two groups of equal size.

All participants underwent detailed clinical and radiographic examination using Cone-beam computed tomography (CBCT) to make sure they adhere to the inclusion requirements followed by phase one therapy before undergoing surgery to ensure tissue health.

For the intervention group the CBCT data imported into specialized software (Mimics21,3-Matic, materialize) for digital planning and creation of case specific guides; one used during cortical lamina harvesting from symphysial area and another guide used for positioning of bone in the planned site. Then the guides were exported as STL (Standard Triangle Language) files and printed from polymer.

Both groups went through all surgical operations under local anesthesia using articaine with vasoconstrictor (Inibsa, Barcelona, Spain), 40 mg/0.01 mg/ml.

The atrophic ridge (recipient site) was exposed using full thickness mucoperiosteal flap followed by buccal cortical bone minute fenestrations to enhance vascularity, followed by exposure of bone harvesting site (donor site) to minimize duration of graft exposure to air deprived from blood supply.

For the intervention group, a special designed bone-supported guide was used to ensure accurate cortical lamina harvesting and minimize potential complications. It was anchored in place anatomically by 2 screws; to be removed after bone harvesting.

Then the harvested cortical lamina was attached to the second guide and all the assembly was anchored into the recipient site using 2 screws. Finally the cortical lamina screwed into the atrophic ridge creating box shape was filled with bone particles (autogenous bone collected from the same donor site mixed with Xenogenic bone in 1:1 ratio) after removal of fixing guide and sharp edges smoothening (fig1).

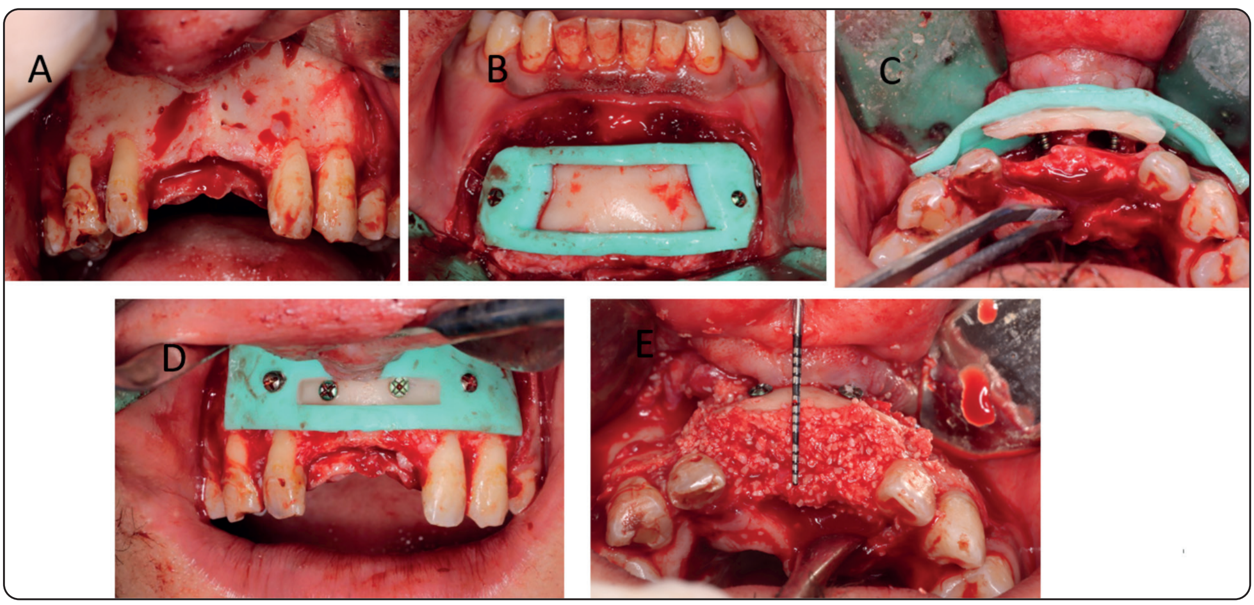

Fig. (1) Intervention case recipient site exposure and preparation(A), positioning of cutting guide (B), fixation of the bone lamina in the defect area with gap maintained(c), frontal view for fixed guide(D), amount of final bone gained(E).

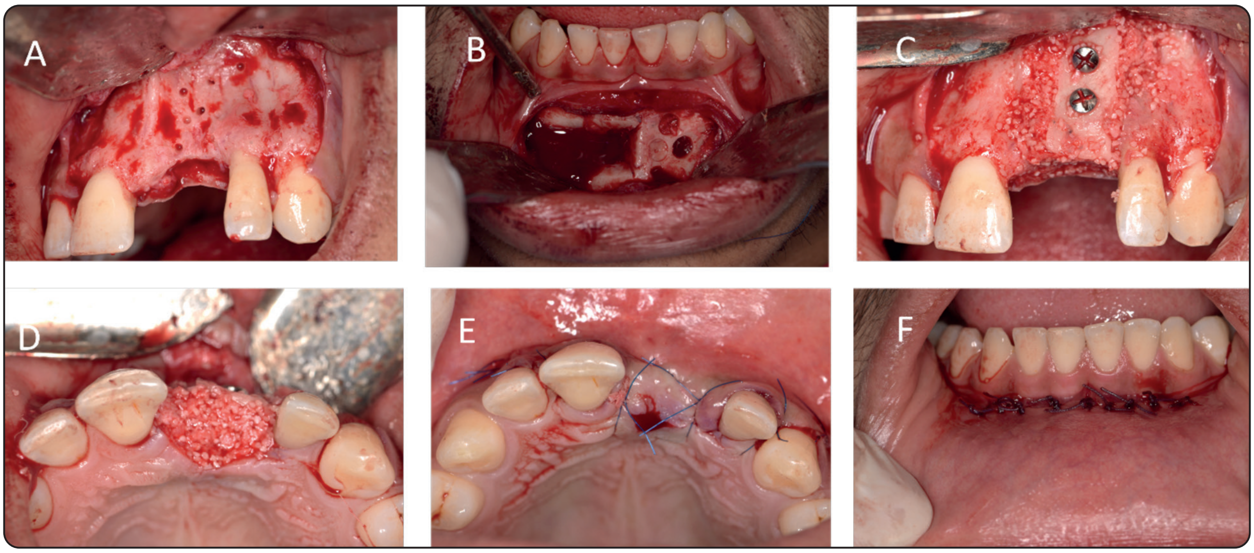

Fig. (2) Free hand case (A) recipient area preparation, (B) cortices harvested from chin area, (C) frontal view after fixation, (D) final occlusal view, (E) closure of recipient site, (F) finally closure of donor site.

The same treatment was performed without a surgical guide for the study group using the free hand technique instead. Based on the operator's visual experience, the size of the cortical shell was manually determine and harvested utilizing a periodontal prop and fixed in the desired position (fig 2).

A stopwatch was used to time the length of the procedure from the first incision to the last and the collected data submitted for statistical analysis Microsoft Office Excel was used for handling of information while SPSS (Statistical package for the social sciences-IBM Corp., Armonk, NY) was utilized for statistical analysis and using the Kolmogorov-Smirnov and Shapiro-Wilk tests to further select the most suited parametric and non-parametric tests, the data were examined for normality.

Since all the variables were confirmed to be regularly distributed, parametric testing was effectively used. To compare the means of the two groups, an independent sample t-test was used.

RESULTS

In total, 14 patients; 9 men and 5 women, participated in this study. They were divided into two groups of seven patients each at random. In the research group, cutting and positioning guides were used entirely during surgery, whereas in the control group, every step was completed freehand. By the end of the first week, as a clinical result in both groups, routine postoperative surgical edema resolved.

Operation duration in minutes

The mean operation duration (min.) in intervention group was (149.57±27.26) minutes, in comparison to (153.86±32.15) minutes in control group, with no statistical significant difference between both groups ($p=0.793$) (table1, fig.3)

TABLE (1) Operation duration (min). in study and control groups

	Groups	Mean	Std. Dev	t value	P value
Operation duration	Study group	149.57	27.26	0.269	0.793 ns
	Control group	153.86	32.15		

Significant level p≤0.05, ns=non-significant

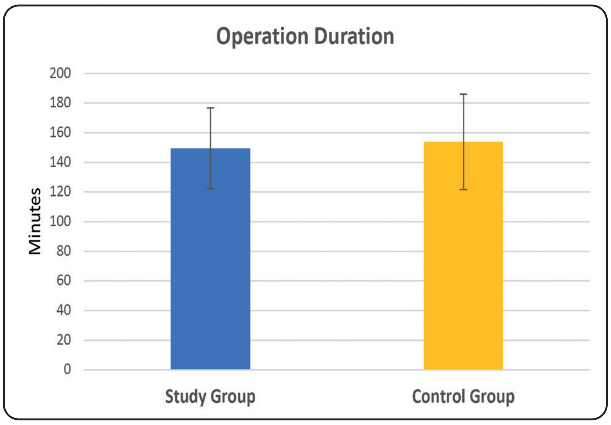

Fig. (3) Bar chart showing means of operation duration in minutes in study and control groups.

DISCUSSION

Alveolar augmentation is a surgical protocol applied to modify the alveolar ridge size and shape in order to receive dental implant for predictable aesthetic, prosthetically driven, and durable Osseo integrated implant[10].

Different augmentation techniques using various bone substitutes and membrane barriers used to gain reconstructed ridges such as distraction osteogenesis, guided bone regeneration using resorbable or non-resorbable membranes, tenting screws, different types of bone blocks [11].

In order to deliver safe, accurate, and predictable outcome using any of the augmentation techniques, computer-aided technology is now regarded as a crucial component of treatment planning and surgical procedure[12].

Cortical lamina grafting technique is a predictable method for lateral ridge reconstruction using a thin creating a box shape containing bone particles to allow for intimate contact between the alveolar ridge and bone particles[13]. This technique of augmentation using 1mm trimmed cortical bone fixed to the atrophic ridge.

Autogenous cortical bone grafting as gold standard procedures are usually time consuming which make the patient annoyed; namely one of its drawbacks.

So, in the present study a computer guided bone grafting was expected to offer a faster solution for better patient experience using a printed stereolithographic replica to convert the virtual planning into the surgical field.

James J Xia et al,2006[14] studied the benefits of using computer aided technology in complicated cranio-maxillofacial surgery and concluded that it provides faster, cheaper, and predictable result compared to conventional protocols.

Also, ***Nassim Ayoub et al,2014***[15] studied the conventional versus computer assisted mandibular reconstruction using vascularized iliac crest bone graft and concluded that computer aided surgery is effective in reducing the grafting procedure duration.

This study showed that the guided surgery is helpful to reduce the graft ischemic duration which is an important factor affecting cells survival and graft success, however, in comparison to conventional technique, time consumption was comparable, as much time was consumed in fixation of the surgical guide itself in the native bone.

CONCLUSION

This study revealed the efficiency of computer aided in bone grafting for augmentation of atrophic ridges, however, with insignificant effect on the operation time.

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