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Procurement of Symphysis block graft using Dynamic navigation : Accuracy Analysis

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Abstract
Background:
In order to restore bone volume in atrophic alveolar ridges, ridge augmentation is an essential operation in dental implantology. Conventional techniques, however beneficial, frequently provide difficulties with accuracy and productivity. With the introduction of dynamic navigation systems to dentistry, there is a chance to improve the precision and results of ridge augmentation operations. With the use of dynamic navigation technology, the accuracy of procuring the block graft is both feasible and accurate.
Materials and methods:
Cadaver mandibles with inadequate alveolar ridges were chosen. The ridge augmentation procedure was led by a dynamic navigation system. A 3D model of the mandible was created using CBCT images for preoperative planning, and the navigation system was incorporated with it. During the augmentation process, real-time tracking and feedback were given by the navigation system during block graft procurement.
Results:
The dynamic navigation system significantly improved the precision of block graft procurement where there was significance in the Apex angular deviation (p value < 0.00) which is important as the underlying vital structures can be properly visualized under Dynamic navigation . Real-time feedback allowed for accurate placement of bone grafts, closely adhering to the preoperative plan. Postoperative CBCT scans confirmed the accuracy of the augmentation, with minimal deviation from the planned augmentation sites.
Conclusion:
The precision and predictability of ridge augmentation in cadaver mandibles can be improved with the use of dynamic navigation technology, as this proof-of-concept study shows. The use of dynamic navigation into clinical practice has promise for enhancing surgical outcomes and mitigating problems linked to conventional ridge augmentation techniques.

I. INTRODUCTION

Dental implants can be placed with a predictable outcome in mind, and implant restorations can continue to function properly for many years following the implant. Still, getting the finest long-term cosmetic results from implant therapy is a challenging task.(1) (2)The principal factor contributing to this problem is the resorption of alveolar bone when teeth are extracted, which causes a significant reduction in the breadth and length of the soft and hard tissues, which leads to the bone grafting procedure, which involves the operator skill.(3)

By using the patient's own tissue, bone grafting is a surgical procedure that can replace damaged bone in a synthetic, natural, or artificial manner. (4)Bone grafting is feasible because bone tissue is capable of regeneration, provided it is allowed room to grow. As there is no longer any intraosseous stimulation from periodontal ligament (PDL) fibers, tooth loss is the source of the insufficient amount of bone, causing the alveolar bone to resorb more quickly.(1,5) A possible indicator of this is the pneumatization of the maxillary sinus following tooth loss. (6)The coronoid process (iliac crest), mandibular symphysis (chin area), and anterior mandibular ramus are examples of non-essential bones from which a bone can be extracted. Autograft lowers the possibility of graft rejection, autogenous bone is the ideal choice for block transplants. It would also be osteoinductive and osteogenic in addition to being osteoconductive.(7)

Numerous clinical applications have shown the successful usage of mandibular symphyseal bone transplants.(8) Their application has been documented in secondary alveolar cleft osteoplasty, orbital floor reconstruction, as an interpositional graft in the management of mandibular and maxillary fractures that do not union or malunion, in conjunction with Le Fort I maxillary advancement, in maxillary sinus grafting, and in acquired alveolar defects prior to endosseous implant implantation.(9)(10)

With the use of dynamic computer assisted surgery, sometimes referred to as guided surgery or surgical navigation, it is able to ascertain the precise location of the surgical drill on the 3D image that is generated from CBCT data.(11) When the surgical procedure is being performed, it directs the physician to the preoperatively intended location. Generally, complex cases where anatomical circumstances—like the closeness of

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the inferior alveolar nerve—need extremely precise surgery to prevent injuries are the ones for which computer guided surgery is suggested. Therefore, understanding these systems' maximum potential variation is crucial for day-to-day clinical practice. Furthermore, to the best of the authors' knowledge, no information has been released regarding the significance of the surgeon's expertise with this kind of technology.

This objective of the study is to demonstrate a secure and viable substitute method for ridge augmentation and subsequent dental operations through dynamic navigation.(12) It describes in detail the many benefits that the trace and place workflow offers in comparison to the fiducial technique in dynamic navigation(13) Using dynamic navigation on a cadaver mandible, a novel method for ridge augmentation during implant placement was carried out.(14)

II. MATERIALS AND METHODS:

This study was conducted on cadaveric mandibles procured from the Anatomy department, Saveetha Dental College using dynamic navigation at Saveetha Dental College, chennai in the month of June - september 202. The Study was approved by the Saveetha Review board with the number : 1904/22/017

Surgical procedure:

Pre Preparations of the cadaveric mandibles were carried out; they were soaked in betadine for 10 minutes to eliminate any infections. Three Salvin screws (*Salvin Dental Specialities, LLC*) of 2*10mm dimensions were used as the trace registration markings as they are preloaded and easily traceable by the Dynamic Navigation Software (*Navident, Canada*). The prepared Mandibles were subjected to Cone beam computed tomography (CBCT) and the DICOM data (Digital Imaging and Communication in Medicine) were loaded to the Navident software. The block graft mode was used to plan the position of the symphysis block graft donor site. The planning was carried out for all the seven mandibles.

The Navident machine was prepared; the cadaveric mandible was mounted on the mannequin and stabilized. Y- jaw tracer with optical sensors were fixed using three screws (Figure 1). The trace registration process was initiated by calibrating the tracer tip with the calibrator; the three Salvin screws that were placed were chosen as the points for trace registration. The registration was carried out by placing the tracer tip on the screws (Figure 1,2). The accuracy of the trace registration co-relating the physical cadaveric mandible with the preloaded/planned CBCT was assessed by placing the tracer tip on the residual teeth; if present, -0.5 - +0.5 values are acceptable accuracy readings.

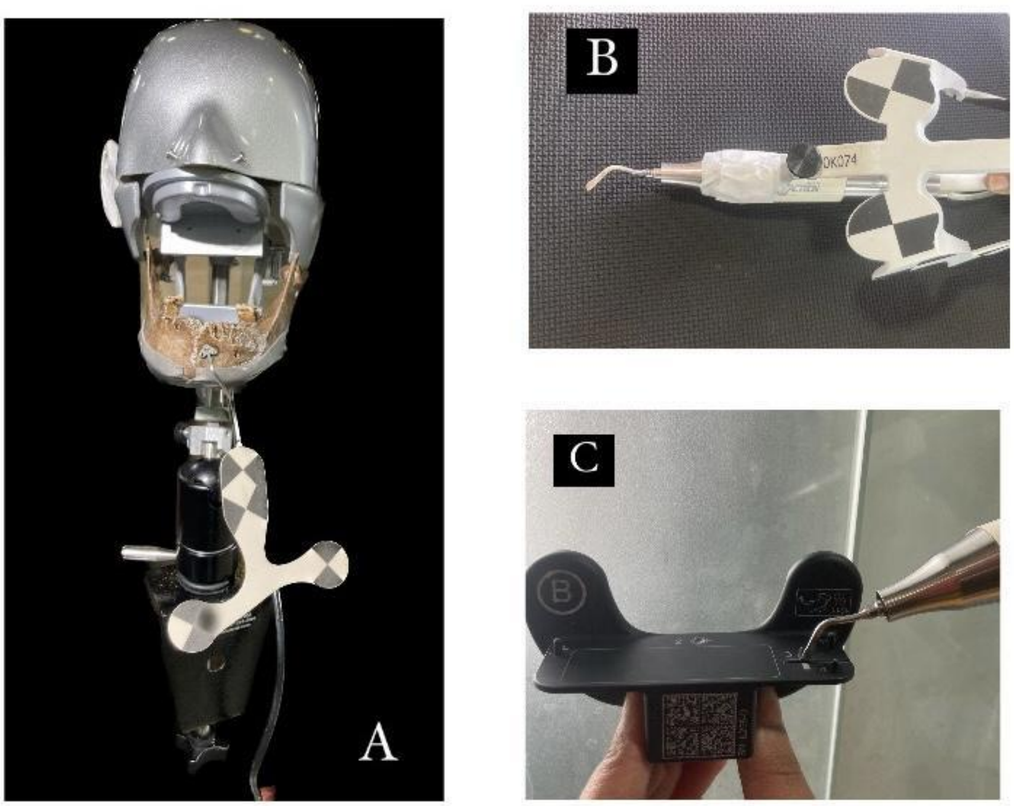

Figure 1 :A. Stabilization of the cadaveric mandible on a mannequin with Y-Jaw tracker, B. Piezo handpiece with the drill tag (with optical sensors), C. Saw (drill tip) calibration with the calibrator.

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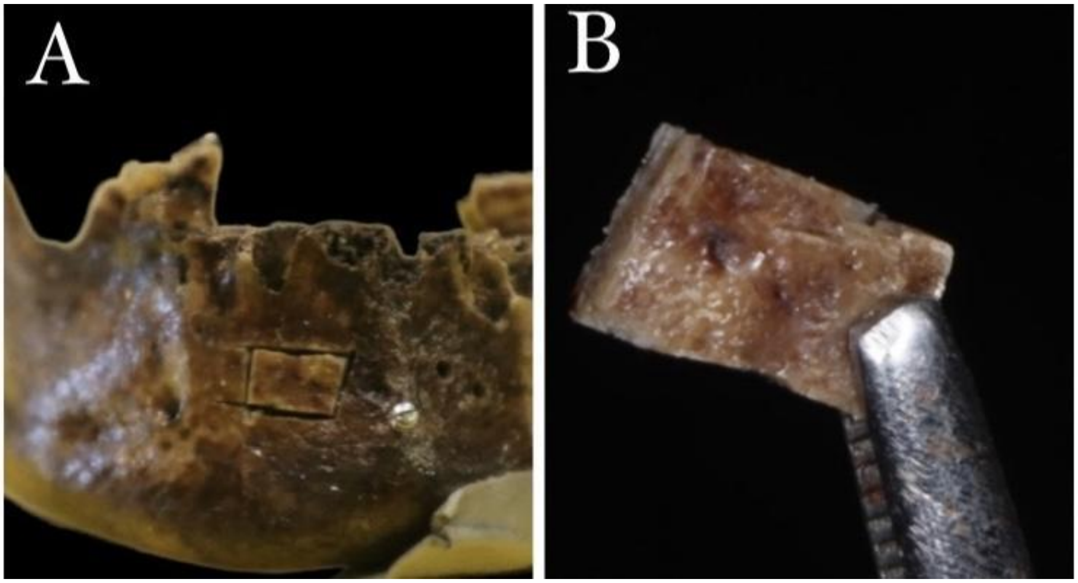

FIGURE 2: A. Different saw cuts carried out using Dynamic navigation, B. Procurement of the block graft from the symphysis.

The Saw mode was activated in the software and the piezoelectric handpiece was used with a drill tag, the piezo tip (for block grafts) was calibrated and the software guided the surgeon in depth and angulation (Figure 2). Once the mesial, distal, upper and lower saw cuts and depth cuts were made, a chisel and mallet was used to procure the block graft (Figure 3).

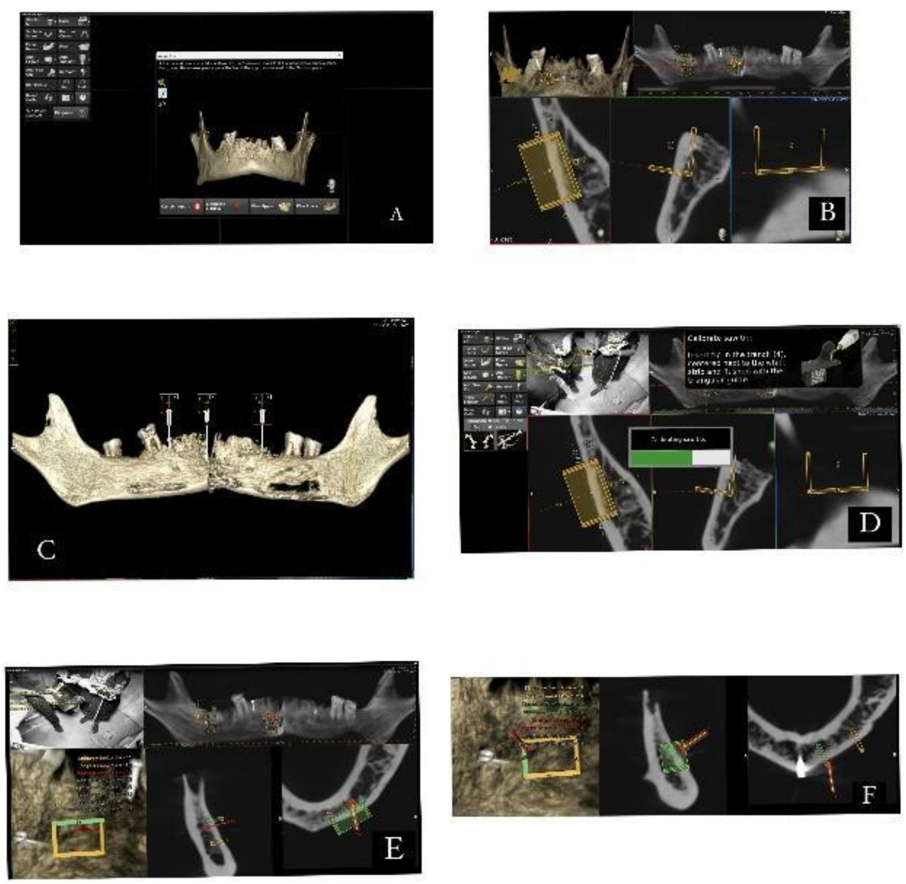

FIGURE 3:A. CBCT loading in the Navident software, B. Planning of saw cuts (Block graft), C. Points of screws taken for calibration, D. Ongoing saw cut using piezo tips, E. Depth cut as shown on the screen

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Post-procurement accuracy analysis:
Once the block graft was procured, The mandible was subjected again to CBCT, (15)the saw cut plan was slightly modified using dental implants overlaid onto the saw cut region. This was used to assess the accuracy of the cuts post procurement of the block graft. (16)The deviations were assessed using Evalunav software, an in-built application under Navident software. The deviation measurements of Entry, Apex deviations (mm) and Apex angular deviation and entry angular;r deviation (degree) were noted for the Mesial saw cut, Distal saw cut, upper saw cut, lower saw cut and depth cut pertaining to the block graft planning (Figure 4).

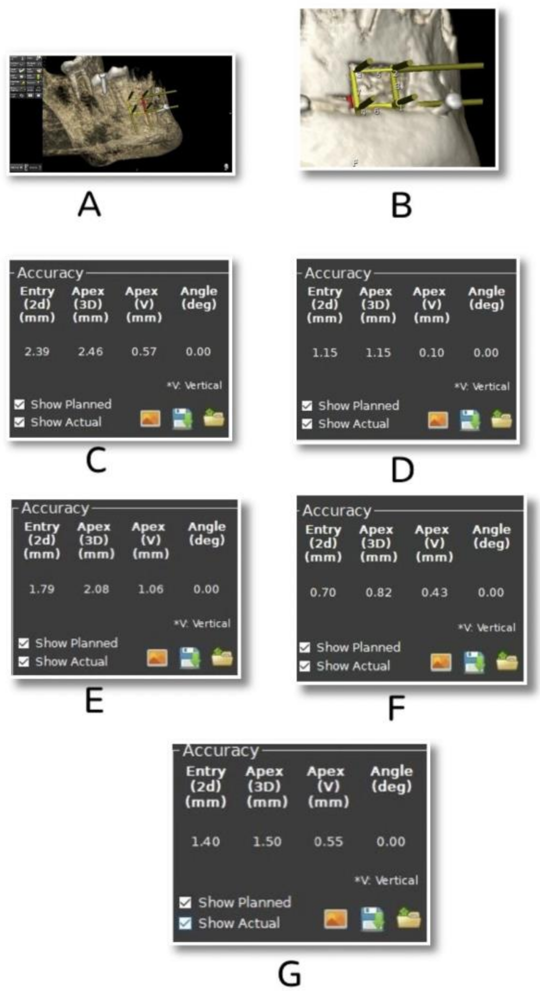

FIGURE 4: A , B. Accuracy analysis using implant planning mode (the saw cuts relined with the implant planning), C.Mesial saw cut, D.Distal saw cut, E.Upper saw cut, F. Lower saw cut, G. Depth cut

III. RESULTS:
The parameters of all the saw cuts that were planned for the procurement of the block graft material were assessed on the basis of Entry, Apex 3 Dimensional (3D), Apex (v-vertical) three parameters in mm (deviation) and Angular deviation in degrees.

IV. ENTRY DEVIATION:
There was almost negligible amount of deviation in terms of the correction positioning of the tips at all the entry points of distal, mesial, upper and lower saw cuts also on the corners taken into consideration as the depth cuts. The least deviation was with the mesial saw cut with a Mean ± Standard deviation of 0.53± 0.15 mm followed by the depth cuts with 0.54±0.17 mm deviation. The maximum deviations were noticed on the distal saw cut with 0.76± 0.17mm deviation. (Table 1) (Figure 5)

		MEAN±STD	MAXIMUM	MINIMUM
ENTRY (mm)	DISTAL SAW CUT	0.76± 0.17(7)	0.98	0.45
	MESIAL SAW CUT	0.53± 0.15(7)	1.25	0.32
	DEPTH CUT	0.54±0.17(7)	1.56	0.26
	UPPER SAW CUT	0.62±0.23(7)	1.76	0.23
	LOWER SAW CUT	0.63±0.25(7)	0.94	0.24

Table 1: Represents the Entry deviations in mm for the different saw cuts that were planned and executed.

APEX 3D DEVIATION:

The apex deviation was noticed for all the saw cuts and the deviation was slightly more than the entry deviations as the handpiece does not have a particular stopping / restricting mechanism, the operating surgeon has to be well versed in haptic feedback mechanism to have this more on point. The maximum deviation was noticed with the depth cuts (corners of the block graft of which the means were taken into consideration) which was 1.62±0.29 mm followed by lower saw cut with 1.57±0.15 mm deviation.(Table 2) (Figure 5)

		MEAN±STD	MAXIMUM	MINIMUM
APEX 3D (mm)	DISTAL SAW CUT	1.24± 0.72(7)	2.46	0.02
	MESIAL SAW CUT	1.56± 0.28(7)	2.71	1.11
	DEPTH CUT	1.62±0.29(7)	1.97	1.23
	UPPER SAW CUT	1.53±0.29(7)	1.96	1.07
	LOWER SAW CUT	1.57±0.15(7)	1.86	1.38

Table 2: Represents the Apex (3D) deviations in mm for the different saw cuts that were planned and executed.

APEX DEVIATION (v):

The 2D deviation in the apex was very minimally deviated in all the saw cuts with the least being the lower and the upper saw cuts with the Mean ± Standard deviation of 0.04±0.18mm. (Table 3) (Figure 5)

		MEAN±STD	MAXIMUM	MINIMUM
APEX DEVIATION (mm)	DISTAL SAW CUT	0.42± 0.33(7)	1.99	0.02
	MESIAL SAW CUT	0.06± 0.23(7)	1.98	1.11
	DEPTH CUT	0.05±0.26(7)	1.97	1.23
	UPPER SAW CUT	0.04±0.17(7)	1.96	1.07
	LOWER SAW CUT	0.04±0.18(7)	1.86	1.38

Table 3: Represents the Apex (V) deviation in mm for the different saw cuts planned and executed.

ANGULAR DEVIATION:
The angular deviation was also negligible with the least deviation noticed with the depth cut followed by the upper saw cut. The mean and Standard deviations are represented in table 4.
(Figure 5)

		MEAN±STD	MAXIMUM	MINIMUM
ANGLE(DEGREE)	DISTAL SAW CUT	0.44± 0.76(7)	1.99	0.01
	MESIAL SAW CUT	0.73± 0.20(7)	0.87	0.36
	DEPTH CUT	0.54±0.22(7)	0.75	0.24
	UPPER SAW CUT	0.52±0.19(7)	0.75	0.23
	LOWER SAW CUT	0.60±0.18(7)	0.76	0.35

Table 4: Represents the Angular deviations of the various Saw cuts in degrees.

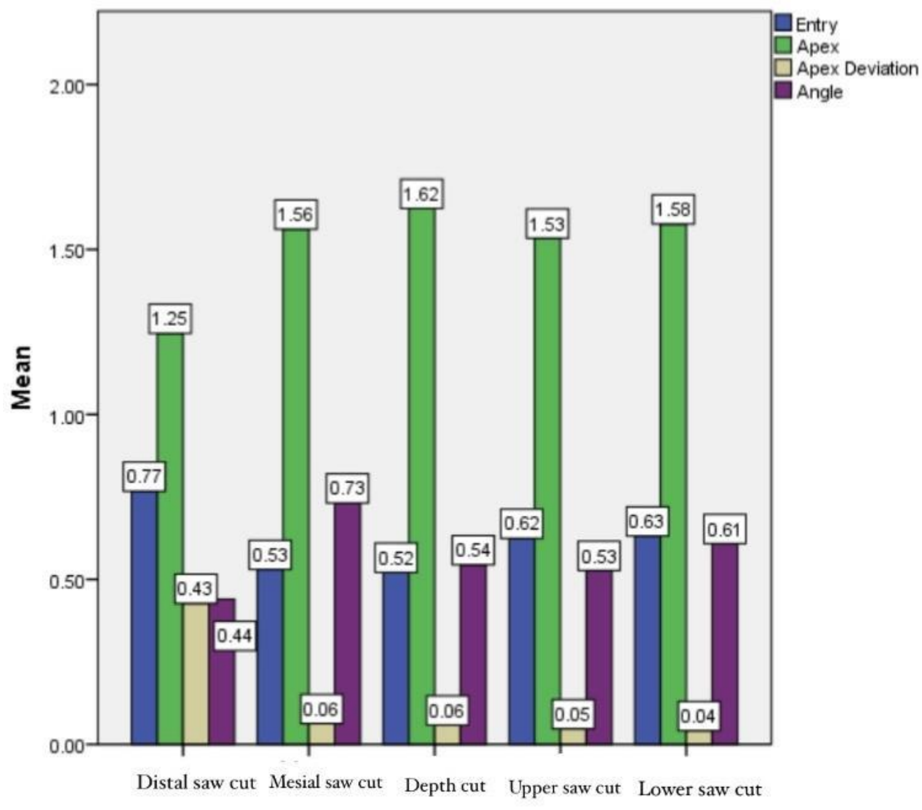

FIGURE 5: Represents bar graph for the deviation of different saw cuts planned and executed

V. DISCUSSION:

Bone splitting, guided bone regeneration (GBR), particle bone grafting, and horizontal alveolar distraction osteogenesis are some of the methods available for treating inadequate alveolar ridge. For the purpose of augmenting bone fragments, autografts, allografts, xenografts, or alloplasts may be utilized. The process of reconstructing an alveolar defect may involve the use of alternate bone filling materials, such as demineralized or freeze-dried bone, or biomaterials like tri-calcium phosphate or hydroxyapatite. Their limitless availability and lack of donor site morbidity are two significant advantages. Nevertheless, these materials come at a higher cost and lack the healing potential and consistency of autogenous bone.

A substitute method for the many procedures mentioned for horizontal alveolar augmentation is ridge splitting.(17) The ridge split approach, however, may have certain drawbacks, such as poor segment vascularity during expansion and undesirable segment fractures in less flexible bone. Alveolar ridge augmentation is now accomplished mostly through alveolar distraction osteogenesis. Either a vertical or horizontal direction might be used to distract the alveolar bone. With the rapid advancement of vertical alveolar distraction, lengthier implants can now be placed. The postoperative difficulties, technical challenges, and patient discomfort during the postoperative period have led to a lack of attention towards horizontal alveolar distraction, which allows implants with a larger diameter.(18)

The use of mandibular bone transplants has become more common these days. Embryologically, the mandible begins as an intramembranous bone. According to certain research, compared to endochondral bone grafts, membranous bone grafts exhibit less resorption and revascularize more quickly. The preservation of the mandibular graft volume is explained by the quick revascularization of the membranous bone graft. (19) Nevertheless, independent of their embryologic origin, several researchers proposed that the volume maintenance of onlay bone grafts depended on whether they were cancellous or cortical. Therefore, the graft microarchitecture functions as a stronger predictor of bone graft survival and more accurately represents the behavior of bone grafts. According to the same investigations, cortical bone grafts showed higher levels of bone morphogenetic protein and lower levels of resorption for onlay bone growth factors than cancellous grafts. (20)It induces the growth of blood vessels from the host bone through various growth factors, such as transforming growth factor or vascular endothelial growth factor.(21) Because cortical bone makes up the majority of mandibular donor grafts, they exhibit good integration and minimal volume loss throughout the brief healing period.(21,22)

Successful block grafting requires precision and skill of the operator and this requires years of clinical experience. (23)This can be to a level circumvented by the use of the new digital methods using computer guidance. Dynamic navigation can be an effective tool for the surgeons to be precise and accurate in their practice. Dynamic navigation does have a steep learning curve, but can be tackled with continuous use of the machine. This also gives the patient comfort during the procedure as they are aware of the procedure that is being performed on them. There are certain drawbacks also associated with the Dynamic navigation usage, the weight of the handpiece, re-calibrations and machine vision related errors. There are very limited studies on graft procurement under Dynamic navigation.

Several studies have evaluated navigation system accuracy, and it is evident that this is a rapidly developing field with enormous potential. However, additional study in this area is still required. It is imperative to emphasize once more that a predicted apical position error, ranging from 1.0 to 2.3 mm, exists even with CBCT and guided surgery, and caution must be exercised to avoid anatomically significant structures.(24)

VI. CONCLUSION:

In terms of precision and clinical results, the acquisition of symphysis block grafts using dynamic navigation has demonstrated encouraging results.(25)The accuracy of graft harvesting is greatly increased by dynamic navigation. (26)Real-time feedback and exact control are made possible by this technology, which lowers the possibility of issues that come with using conventional freehand methods.It may be possible to shorten the total surgery time by using dynamic navigation. A more efficient process results from accurate guidance, which reduces the need for intraoperative changes and corrections.

Patient safety is also considered when graft procurement is done with greater accuracy since there is less chance of causing harm to nearby anatomical tissues. (27)This is especially crucial in sensitive regions like the mandibular symphysis. (28)Dynamic navigation may end up becoming the norm for graft harvesting, providing a more dependable and secure option than current techniques.(29) Better patient outcomes and greater confidence among the medical professionals doing these treatments could result from this technology.(30) These results need to be confirmed by bigger sample sizes and long-term follow-up studies in order to fully investigate the possibilities of dynamic navigation in different grafting processes.

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