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Accuracy of Harvesting Autogenous Block Grafts from the Mandibular Ramus Using Navident Dynamic Navigation: A Cadaveric Study

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ABSTRACT

Background: The atrophy of alveolar ridges after missing teeth extraction requires block procedures based on autogenous tissue for implants to achieve successful outcomes. Practitioners prefer the mandibular ramus to harvest bone grafts because of its excellent quality and minimal side effects yet extraction remains complex because of important anatomical structures in this area. An evaluation of Navident dynamic navigation for ramus block graft extraction accuracy takes place on cadaveric mandibles through this study.

Materials and Methods: The clinical procedure involved block graft harvesting under Navident guidance for eight cadavers during June-September 2024 at Saveetha Dental College. The surgical plans benefited from CBCT scans that enabled titanium screws to perform trace registration. Evaluations through CBCT and Evalunav software measured entry (2D), apex (3D), apex (vertical) and angular deviations regarding basal, mesial and distal saw cuts.

Results: The entry point deviations were minimal as the baseline measurement was 0.24 ± 0.03 mm while mesial was 0.29 ± 0.04 mm and distal was 0.24 ± 0.03 mm. Apex (3D) deviations achieved their maximum value at 0.31 ± 0.04 mm (basal). The mesial orientation showed minimal apex (vertical) deviations of 0.04 ± 0.02 mm while angular deviations reached their peak level at 1.56 ± 0.12° in the same area. The recorded deviations proved to be inside acceptable clinical parameters.

Conclusion: The dynamic navigation system provides enhanced accuracy and safety for ramus block extraction procedures in situations where complex implant procedures require its use. Big sample-based research should follow to verify these observed results.

1. INTRODUCTION

Ridge deficiencies need proper restoration to guarantee successful implant dental outcomes. Alveolar bone experiences fast deterioration after extraction which creates spaces not suitable for implant placement prediction. Regaining lost hard tissue through ridge augmentation procedures becomes necessary before implant placement can be accomplished [1]. Autogenous block grafting procured from intraoral locations has established itself as the leading treatment for bone augmentation because it shows strong osteogenic and osteoinductive and osteoconductive properties[2] . Medical researchers identify the mandibular ramus as an ideal intraoral source because it provides high-quality cortical bone with outstanding structural properties and demonstrates minimal bone loss after harvesting[3]. The desirable location of mandibular ramus along with its minimal aggressive response after surgery and fast surgical procedure time makes it a preferred choice for dental professionals as a donor site [4].

Performing an extraction for block graft from the ramus requires extreme technical skill. Surgical precision must be high since the delicate position of the inferior alveolar nerve and lingual nerve and external oblique ridge near the surgical area while offering restricted visibility [5]. Therapists currently rely on freehand techniques to extract the grafts which depend on their dental experience and anatomical familiarity with the area. Such methods successfully achieve their objectives but operators must recognize that they increase the risk of intraoperative errors together with graft fractures and the injury of nearby tissues [6]. The adoption of dynamic navigation systems in oral and maxillofacial surgery protocols represents a revolutionary advancement observed over the last few years. Dynamic navigation systems process information in real time to show the cutting instrument location in three-dimensional space as it relates to preoperative imaging [7]. Ramus defines a specific surgically sensitive area where the technology enables better accuracy while reducing mistakes and ensuring higher safety standards[8] .

The Dynamic Navigartion system performs trace registration data correlation that matches CBCT images to patient anatomy through basic intraoperative landmarks[9] . Real-time surgical guidance becomes available to surgeons after calibration through the system which supplies information about stern osteotomy depth and positioning alongside angular measurements. Evidence shows dynamic navigational systems have thorough research for implant procedures and sinus lifts but their usage for extracting ramus block grafts requires more investigation[10]. This research investigates whether it is feasible and precise to obtain autogenous block grafts from mandibular ramus through the use of Navident dynamic navigation. Post-procedure CBCT scans of cadaveric mandibles serve as evidence to demonstrate that dynamic surgical navigation guides surgeons in acquiring exact and dependable and secure ramus bone grafts. The study results will facilitate the broader acceptance of surgical graft procedures using navigation systems while enhancing safety measures in complex surgical practices[11].

2. MATERIALS AND METHODS

This in-vitro cadaveric study was conducted at the Department of Implantology, Saveetha Dental College and Hospitals, Chennai, between June and September 2024. Ethical approval was obtained from the Institutional Review Board of Saveetha University (Approval No: 2307/24/018).

Study Design and Sample Selection

Eight human mandible specimens from the Department of Anatomy constituted the study sample. Research only used specimens that maintained unaltered posterior mandibular structures combined with preserved ramus anatomy. The study excluded mandibles presenting any of the following conditions: traumatic injuries or surgical defects or extensive bone tissue loss within the donor site.

Pre-Surgical Preparation

The mandibles received a 10-minute immersion in 5% povidone-iodine solution to achieve disinfection after which they received secure mounting on mannequins for surgical stabilization. Three titanium tracing screws measuring 2.0 mm by 10 mm from Salvin Dental Specialties (USA) were inserted into available cortical bone regions near the mandibular ramus for dynamic navigation software registration. The biomodels underwent Cone Beam Computed Tomography CBCT imaging with defined scanning parameters during each test. Processing of DICOM data was followed by importing the data into Navident software from ClaroNav (Toronto, Canada) for surgical planning operations.

Surgical Planning

Using the “Bone Graft” mode in Navident, the ramus block graft outline was virtually designed on each specimen in accordance with anatomical landmarks. The dimensions of the block were standardized across all specimens (approximately 20 mm x 10 mm x 4 mm), with safe margins maintained from the mandibular canal, external oblique ridge, and posterior border of the ramus. Saw cuts were planned in five directions:

- Mesial and distal vertical osteotomies
- Superior and inferior horizontal osteotomies
- A depth cut to define the thickness of the graft

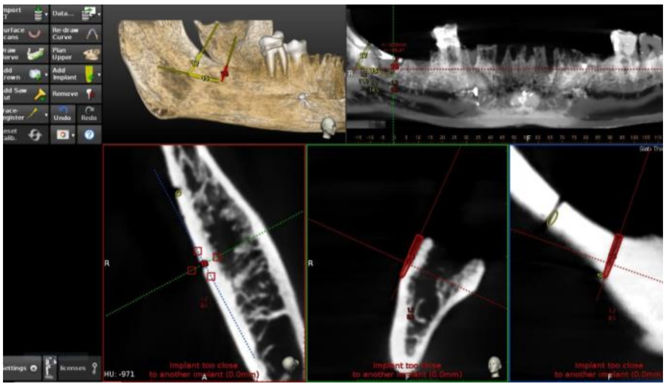

Fig 1: Planning of the saw cuts in Navident Software

Navigation Setup and Calibration

The dynamic navigation system received its calibration through a process which involved fixing a Y-Jaw tracking arm and mounting optical markers onto the surgical handpiece. The Mectron Piezosurgery® piezoelectric handpiece needed calibration together with the tracer tip through the designated Navident calibrator. A trace registration procedure involved using the titanium screws installed earlier for the process. The tracer tip placement against anatomical landmarks or remaining teeth checked accuracy by staying within a ±0.5 mm range before starting the surgical intervention.

Block Graft Harvesting Procedure

The Saw mode in Navident was activated. A piezoelectric saw tip suitable for bone block harvesting was used, and its real-time position was continuously displayed on the Navident interface. Each osteotomy was performed according to the planned trajectory and depth, following the software guidance. The following sequence was used for each ramus:

- Mesial and distal cuts to define the anterior-posterior limits
- Superior and inferior cuts to establish vertical height
- Depth cut made perpendicular to the surface to delineate thickness

Following the osteotomies, a surgical mallet and chisel were used to carefully dislodge and retrieve the graft block.

Postoperative Assessment and Accuracy Analysis

Second CBCT imaging was procured after the graft retrieval phase. Evalunav, a built in accuracy evaluation tool from Navident softwarewas used to analyze superimposed initial surgical plan and postoperative scan. The following set of parameters was recorded for every single cut out of the five:

- Entry Point Deviation (mm) – difference at the surface level
- Apex Deviation (3D, mm) – discrepancy at the depth of the cut
- Vertical Apex Deviation (v, mm) – vertical-specific deviation
- Angular Deviation (°) – difference in planned vs executed cut angulation

All measurements were recorded and tabulated for descriptive statistical analysis.

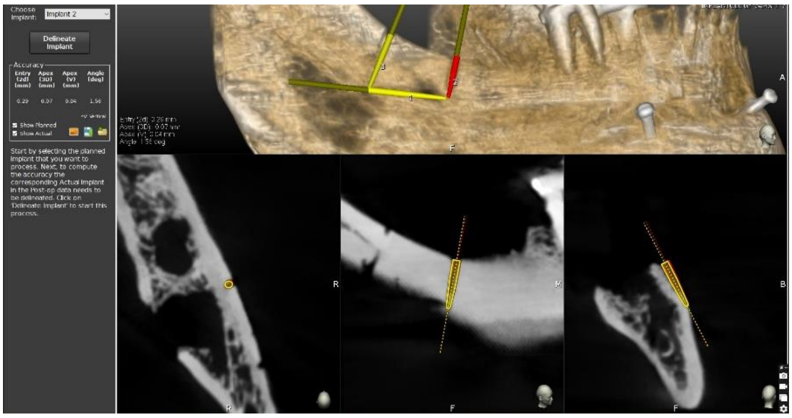

Fig 2: Evaluating the basal saw cut to the planned cut

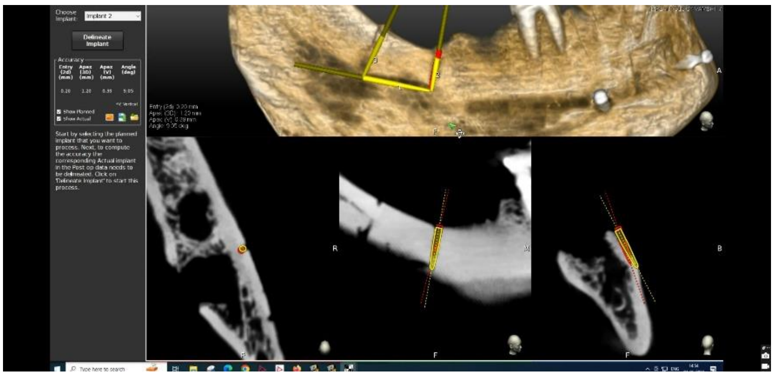

Fig 3: Evaluating the mesial saw cut to the planned cut

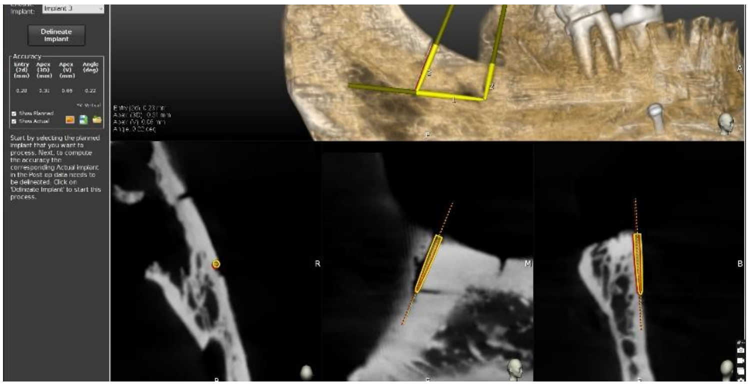

Fig 4: Evaluating the distal saw cut to the planned cut

3. RESULTS

ENTRY DEVIATION:

There was almost negligible amount of deviation in terms of the correction positioning of the tips at all the entry points of the basal, mesial, and distal saw cuts. The least deviation was with the mesial saw cut with a mean ± standard deviation of 0.29 ± 0.04 mm, followed by the basal saw cut with 0.24 ± 0.03 mm deviation. The maximum deviation was noticed on the distal saw cut with 0.24 ± 0.03 mm deviation. (Table 1)

ENTRY (mm)	Mean ± STD	Maximum	Minimum
Basal	0.24 ± 0.03 (8)	0.28	0.2
Mesial	0.29 ± 0.04 (8)	0.34	0.24
Distal	0.24 ± 0.03 (8)	0.28	0.2

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 was slightly more than the entry deviations as the handpiece does not have a particular stopping/restricting mechanism, requiring the operating surgeon to be well versed in haptic feedback mechanisms for precision. The maximum deviation was noticed with the basal saw cut, which was 0.31 ± 0.04 mm, followed by the distal saw cut with 0.15 ± 0.04 mm deviation. (Table 2)

Apex Deviation(mm)	Mean ± STD	Maximum	Minimum
Basal	0.31 ± 0.04 (8)	0.36	0.26
Mesial	0.07 ± 0.03 (8)	0.11	0.03
Distal	0.15 ± 0.04 (8)	0.20	0.10

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 mesial saw cut with a mean ± standard deviation of 0.04 ± 0.02 mm. (Table 3)

APEX DEVIATION (mm)	Mean ± STD	Maximum	Minimum
Basal	0.06 ± 0.02 (8)	0.09	0.03
Mesial	0.04 ± 0.02 (8)	0.07	0.01
Distal	0.15 ± 0.03 (8)	0.19	0.11

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 basal and distal saw cuts, both at 0.22 ± 0.05°, while the mesial saw cut showed a higher deviation of 1.56 ± 0.12°. The mean and standard deviations are represented in Table 4.

ANGLE (DEGREE)	Mean ± STD	Maximum	Minimum
Basal	0.22 ± 0.05 (8)	0.28	0.16
Mesial	1.56 ± 0.12 (8)	1.70	1.42
Distal	0.22 ± 0.06 (8)	0.29	0.15

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

4. DISCUSSION

This research proves both the accuracy and practical implementation of Navident dynamic navigation to extract autogenous block grafts from mandibular ramus in eight cadaveric mandibles for implant dentistry treatment of atrophic alveolar ridges. The observed Navident entry deviations matched previous reports by Hamitha et al. (2024) [1] about Navident symphyseal grafting accuracy below 0.76 mm. Data consistency indicates that Navident shows precision in placing the tip position accurately despite working in the complex shape of the mandibular ramus where additional deviation may result from its proximity to the external oblique ridge [12].

The Apex (3D) deviations reached their maximum point at 0.31 ± 0.04 mm for basal cut sections due to an important weakness in dynamic navigation systems which uses only haptic feedback for precision without a mechanical stop in the handpiece [13]. The mesial cut demonstrated lower deviation at 0.07 ± 0.03 mm according to results presented by Parekar et al. (2024) [14]who found real-time guidance improves accuracy in implant procedures. The results from basal and distal cuts (0.15 ± 0.04 mm) demonstrate the need to upgrade navigation software algorithms or enhance feedback mechanics because Yang et al. (2024) recommended ongoing improvement in navigation system technologies. The perpendicular alignment of depth cuts in the basal region could be the reason behind increased deviations and operator precision becomes essential for maintaining control[4].

Apex (vertical) deviations presented minimal numbers due to the mesial cut measuring at 0.04 ± 0.02 mm which matches the findings of previous cadaveric validation for Navident's vertical alignment functions[15]. Precision becomes crucial in clinical practices due to the iatrogenic risks so the higher deviation of 0.15 ± 0.03 mm at the distal cut stems from its nearness to the important inferior alveolar nerve[16]. The mesial cut showed greater deviation (1.56 ± 0.12°) when compared to the basal (0.22 ± 0.05°) and distal (0.22 ± 0.06°) cuts indicating potential operator or anatomical factors, which was also observed by Khan et al. (2024) [6]during their navigation study. Stray observations from the mesial cut require focused practice in addition to software enhancements to boost accuracy in cutting performance.

The real-time tracking system along with preoperative planning capabilities of Navident provides superior benefits by decreasing sensitivity complications that can arise during freehand procedures in the ramus area according to research by Narde et al. (2024)[17]. The reliability of the Navident system for ramus harvesting has been established through consistent results from eight mandible cases because this site possesses both high osteogenic potential and low morbidity rates[18]. The cadaveric model restricts researchers from detecting soft tissue adjustments and bleeding incidents together with patient-specific adaptations that might affect treatment final results. The restricted number of samples in this study decreases its ability to represent broader patient populations just like other proof-of-concept research.

The scientific community needs to conduct extensive research on living patients and graft models because they will help validate adaptation dynamics and measure complete implant success. The research of Mangano et al. (2024)[9], [19]explains how advanced haptic feedback and machine learning algorithms can increase cut precision at both apex points and angular directions especially when performing deep incisions. The research discoveries provide guidance for intricate pediatric and neonatal surgical procedures because they could make Navident a standard instrument that assists in extracting tissue grafts near important structures.

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