Comparative Assessment of Single drilling System Versus Conventional Implant Site Preparation in the posterior Maxilla.

Abstract

Purpose: This study aimed to evaluate the effect of two implant site preparation techniques single drill and conventional drilling on implant stability and marginal bone loss following implant placement in the posterior maxilla. **Materials And Methods:** A total of 20 patients aged 20–50 years with missing teeth in the posterior maxilla were included in this study. Participants were randomly allocated into two groups: Group I (single-drill technique) and Group II (conventional drilling technique), with 10 patients in each group. Implant stability was assessed using resonance frequency analysis (ISQ), while marginal bone loss was evaluated radiographically after six months. **Results:** The single-drill group demonstrated a significantly shorter drilling time compared with the conventional drilling group ($P < 0.001$). Postoperative pain scores showed a significant reduction over time in both groups, with no statistically significant difference between them ($P > 0.05$). The single-drill technique exhibited higher primary stability than the conventional drilling method, whereas both groups showed a significant increase in implant stability after the healing period with no significant difference in secondary stability. No statistically significant differences were observed between the two groups regarding marginal bone loss at any implant surface. However, within both groups, the buccal surface showed slightly higher bone loss compared with other surfaces. **Conclusion:** Within the limitations of this study, both drilling techniques achieved successful clinical outcomes. The single-drill approach significantly reduced surgical time and provided higher primary stability, while maintaining comparable postoperative pain levels, secondary stability, and marginal bone loss to conventional drilling. Therefore, the single-drill technique can be considered an efficient and reliable alternative for implant placement in the posterior maxilla.

Key words:
Conventional drills,Single drilling system

Introduction: -

Achieving predictable osseointegration is considered a fundamental factor for the long-term success of dental implants. Osseointegration, first described by Brånemark, refers to the direct structural and functional connection between the implant surface and the surrounding bone without the presence of fibrous tissue(1). One key aspect shaping this biological mechanism is the type of implant material used. Another contributor involves how the implant is designed structurally. Surface traits also play a role, influencing integration at the cellular level. The density and volume of surrounding bone matter just as much. Surgical precision during placement affects outcomes significantly. How force is applied to the implant after insertion completes the picture - Albrektsson et al grouped these six elements together when analyzing successful implantation (1).

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One key factor stands out - primary implant stability - as vital for proper osseointegration. Without it, micromovements may occur while healing unfolds; this depends heavily on the implant design, surgical protocol, and bone density (2). In posterior maxilla, implant placement is a clinical challenge because bone tends to be of lower density, typically rated D3 or D4 in quality. The decreased bone density may lead to implant in stability, therefore preparing the site demands precision, gentle handling, and sharp attention to detail during surgery (2, 3).

Implant osteotomy preparation heavily influences implant stability and the biological response of the surrounding bone. Most often, dentists rely on conventional sequential drilling to shape the area. Starting small and working up, they use progressively larger diameter drills - each pass carefully cooled with steady fluid flow - to prevent overheating and protect living tissue.However, excessive heat during drilling may result in thermal bone injury and potential bone necrosis if the temperature exceeds the critical threshold(4).

Although the conventional drilling protocol has demonstrated predictable clinical outcomes, the use of multiple drilling steps may increase surgical time and procedural complexity. In recent years, simplified osteotomy preparation techniques have been introduced with the aim of improving surgical efficiency while maintaining adequate implant stability and minimizing surgical trauma(5).

One of these approaches is the single-drill (hollow drill) system, which allows the preparation of the implant osteotomy using a single drilling step rather than multiple sequential drills. This system has been proposed to reduce surgical time, minimize bone removal and microfractures, and allow the harvesting of bone cores that can be used as autogenous grafting material(6, 7).

Therefore, the aim of the present study was to evaluate the marginal bone changes and implant stability associated with single-drill and conventional drilling techniques for implant placement in the posterior maxilla.

Subjects and Methods: -

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Study population:

This clinical study included 20 patients between 20 and 50 years of age who presented with missing teeth in the posterior maxillary region and were candidates for delayed dental implant placement. All participants were recruited from the outpatient clinic of the Department of Oral Medicine, Periodontology, Oral Diagnosis, and Radiology, Faculty of Dentistry, Mansoura University.

The institutional ethical committee, which assigned Ethical approval number:A04010240M).Reviewed and approved the study protocol. Before enrollment, all patients received detailed information about the study's purpose, the surgical procedures involved, potential risks, and other treatment options. Written informed consent was obtained from all participants.

Group Allocation and Randomization:

The recruited patients were randomly allocated into **two equal groups**, with all implants placed in the posterior maxilla.

Group I (Single-Drill Group):

Included 10 patients who underwent implant placement using the **singledrilling technique**.

Group II (Conventional Drilling Group):

Included 10 patients who received implants using the **conventional drilling protocol**.

Randomization was conducted by a senior resident who was not involved in the surgical procedures and remained blinded to the intervention protocols. Allocation was performed using a computer-generated randomization sequence through SPSS

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software (version 25.0) to ensure equal and unbiased distribution of participants between the two groups (Fig. 1).

Eligibility Criteria:

Inclusion Criteria

Patients were included in the study if they fulfilled the following conditions:

- Residual bone height greater than 8 mm
- Available alveolar bone width of at least 6 mm
- Adequate keratinized gingival tissue
- Favorable occlusal relationship
- Good oral hygiene status
- Ability and willingness to attend follow-up appointments

Exclusion Criteria:

Patients were excluded from the study if any of the following conditions were present:

- Insufficient bone width (less than 6 mm mesiodistally or buccolingually)
- Presence of uncontrolled systemic diseases that could interfere with bone healing
- History of radiotherapy to the head and neck region within the previous 12 months
- Heavy smoking (more than 20 cigarettes per day) according to WHO criteria
- Patients unable or unwilling to comply with the required recall visits

Sample Size Calculation:

Sample size calculation was performed utilizing G Power software (version 3.1.9.4) (8). Given an effect size of 0.7954, along with a significance threshold of $\alpha = 0.05$ and desired power set at 95% ($1-\beta = 0.95$), analysis indicated that at least 20 individuals would be necessary. Ten people were allocated to each group within the study design.

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Although modest in scale, this number allowed detection of meaningful statistical contrasts between the two implant osteotomy methods tested here. The approach ensured enough sensitivity to observe relevant effects under the conditions of this randomized trial.

Surgical Procedure:

Preoperative Assessment

Prior to surgery, all patients underwent cone beam computed tomography (CBCT) examination to assess bone density and evaluate the available bone volume at the proposed implant site. In addition, routine laboratory investigations including complete blood count (CBC), bleeding time (BT), and international normalized ratio (INR) were performed to ensure a normal bleeding profile.

Each patient received 1 g Amoxicillin–Clavulanate (Epico Co., Egypt) one hour before the surgical procedure as antibiotic prophylaxis, followed by the same dose every 12 hours for seven days after surgery.

Local anesthesia was achieved using 4% articaine with 1:100,000 epinephrine (Septanest SP, Cedex, France).

A crestal incision was made followed by elevation of a full-thickness mucoperiosteal flap to expose the alveolar bone (Figs.2A,3A).

A stereolithographic surgical guide was then positioned to ensure precise and accurate preparation of the implant osteotomy site.

Osteotomy Preparation:

Single-Drill Technique (Group I)

For patients in this group, implant osteotomy preparation was performed using a specially designed single hollow drill system (HaeNaem Co., Ltd., South Korea). The

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osteotomy was prepared using a single drilling step at a rotational speed of 800–1000 rpm under copious saline irrigation to minimize thermal injury to the surrounding bone (Fig.2B).

Conventional Drilling Technique (Group II)

In this group, implant site preparation was performed using conventional drills (DIO Implant System, DIO Corporation, Busan, South Korea). The procedure started with a 2.3 mm pilot drill, followed by sequential enlargement of the osteotomy until the final diameter of 3.4 mm was achieved. All drilling steps were carried out at 800 rpm with continuous saline irrigation (Fig.3B).

Implant Placement

All implants used in the present study were DIO implants (DIO Implant System, Korea). The implants were inserted with an insertion torque ranging between 35 and 40 N·cm and positioned approximately 1 mm below the crestal bone level.

Primary implant stability was measured immediately after placement using Resonance Frequency Analysis (Osstell®, Integration Diagnostics AB, Sweden).

After implant insertion, cover screws were placed(Figs.2D,3D) and the mucoperiosteal flaps were repositioned and sutured using 5-0 polypropylene sutures (Prolene®, Ethicon Inc., USA).

Second-Stage Surgery

A healing period of four months was allowed before performing the second-stage surgery. Prior to the procedure, patients were instructed to rinse for 30 seconds with 0.12% chlorhexidine mouthwash.

Under local anesthesia, the surgical guide was repositioned and a tissue punch drill was used to expose the cover screw with minimal soft tissue removal. The cover screw was

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then removed and replaced with a healing abutment of appropriate dimensions to establish a proper emergence profile.

Clinical Evaluation:

Pain Assessment

Postoperative pain was assessed using a 10-point Visual Analog Scale (VAS) at different time intervals: 24 hours, 72 hours,7 days and 14 days(9).

Implant Stability Measurement

Implant stability was measured using Resonance Frequency Analysis (Osstell®) at two time points:

- Immediately after implant placement (T0), (Figs.2C,3C).
- Four months after implant placement (T1), (Figs.2E,3E).

Drilling Time

The total time required for implant osteotomy preparation was recorded in minutes for each surgical technique.

Radiographic Evaluation

Digital Periapical Radiography

Digital periapical radiographs were taken immediately after implant placement to confirm correct implant positioning.

Cone Beam Computed Tomography (CBCT)

CBCT scans were obtained six months after implant placement to evaluate crestal bone changes surrounding the implants.

Marginal bone loss was assessed at four implant surfaces:

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- Mesial
- Distal
- Buccal
- Lingual

Panoramic reconstructed images were used for mesial and distal measurements (Figs.2I,3I), while cross-sectional views were used to evaluate buccal and lingual bone levels (Figs.2J,3J). The **average value of the four measurements** around each implant was calculated and used for further statistical analysis.

Prosthetic Phase

Digital intraoral impressions were obtained using an intraoral scanner (Medit i700, Medit Corp., Seoul, South Korea) approximately 2–3 weeks after the second-stage surgery.

Following removal of the healing abutment, the gingival emergence profile was scanned and the scan body was positioned and scanned. The opposing dentition and maxillomandibular relationship were also recorded. After scanning, healing abutments were reinserted.

The digital files were transferred to the dental laboratory via cloud-based software. Appropriate Ti-base abutments and gingival heights were selected from the implant library. The screw-retained crowns were then designed and fabricated (Figs.2F,3F), and finally tightened using a torque of25N force. (Figs.2G, H,3G, H,).

Statistical Analysis:

Statistical analysis was carried out using SPSS software version 22 (SPSS Inc., Chicago, IL, USA).

Normality of data distribution was assessed using the Kolmogorov–Smirnov test and the Shapiro–Wilk test.

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- VAS scores and marginal bone loss (MBL) were expressed as mean ± standard deviation.
- Independent t-test was used to compare drilling time between the two groups.
- Repeated measures ANOVA was used to compare VAS scores and implant stability values at different observation times.
- Two-way ANOVA was applied to compare marginal bone loss between groups and implant surfaces.

A P-value < 0.05 was considered statistically significant.

Results:-

The results of the present study are summarized in the following tables and figures. A total of **20 patients** were included and randomly allocated into two groups: the **single-drill group** and the **conventional drilling group**. Clinical and radiographic parameters were evaluated, including demographic characteristics, operative drilling time, postoperative pain scores, implant stability, and marginal bone loss around the dental implants.

Comparisons were performed between the two groups to assess the effect of the drilling technique on the evaluated outcomes. The findings are presented in detail in the corresponding tables and figures.

Demographic data of the study population:

Table one presents participant demographics. Averaging 37.90 years, the single-drill group showed fluctuations of 3.28 years. The standard drilling cohort sat at 38.70 years on average, with deviations measuring 2.83 years. Despite minor differences in central tendency, statistical evaluation detected no meaningful divergence between groups (P = 0.56). Though numerically distinct, age patterns remained comparable across conditions**.**

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Half the participants in the single-drug group were men; by comparison, 60 percent of the standard care sample identified as male. This difference, upon testing, turned out not to be statistically meaningful (P = 0.65).

Drilling time (in minute):

Time needed to prepare implant sites is listed in Table (2). With the single-drill system, average duration came to 0.493 minutes, give or take 0.011; on the other hand, conventional technique required 1.49 minutes, varying by 0.041. The difference between methods proved large - verified statistically under a threshold of P less than 0.001. Clearly seen: cutting down drills reduced overall timing compared to routine steps.

Visual analogue scale (VAS):

Examining graph (1), VAS scores reflect postoperative pain levels measured at different points. As weeks passed, individuals in each group experienced reduced pain intensity - this pattern stood out clearly through statistical analysis (P < 0.001). Yet even though improvement occurred consistently, differences between the single-drill method and conventional technique failed to reach significance during any follow-up period (P > 0.05).

Implant stability:

Implant stability values measured using resonance frequency analysis (ISQ) are presented in graph(2). In the single-drill group, the mean primary stability was 70.60 ± 1.57, which increased significantly to 78.20 ± 2.57 after four months (P < 0.001). Similarly, in the conventional drilling group, implant stability increased significantly from 61.10 ± 3.74 at implant placement to 76.50 ± 2.91 after four months (P < 0.001).

When comparing the two groups, the single-drill group demonstrated significantly higher primary stability than the conventional drilling group (P < 0.001). However, no

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statistically significant difference was observed between the two groups regarding secondary stability (P > 0.05).

Marginal bone loss:

Marginal bone loss at different implant surfaces is illustrated in graph (3). The buccal surface showed the highest mean bone loss values in both groups. However, no statistically significant differences were observed between the single-drill and conventional drilling groups at any implant surface (P > 0.05).

Discussion:-

The present clinical study evaluated the influence of two implant site preparation techniques of single-drill and conventional drillingon implant stability, marginal bone loss, and surgical efficiency in the posterior maxilla. Both groups' results showed favorable clinical and radiographical outcomes. Each approach worked well under consistent conditions. Outcomes matched closely despite differing methods indicating that Precision played a role every time. Stable integration emerged reliably where basics were respected.

One notable change stood out in drilling time - using single drill method cut the time sharply: 0.49 minutes on average, versus nearly triple that with conventional sequential drilling technique at 1.49 minutes, a gap confirmed as highly significant (P < 0.001). Backed by earlier findings - Guazzi et al.(5), Rugova et al.(10), and Bisher et al.(11), - the idea that single-drill methods quicken osteotomy without risking implant stability or raising thermal risk has solid roots. Efficient sequences reduce procedural complexity, which may ease physical load during surgery. Because operations take less time, individuals often report feeling more at ease throughout the process. Shorter interventions tend to lessen physiological tension mid-surgery. When applied clinically, such efficiency shifts single-step techniques from theory toward practical advantage**.**

When examining postsurgical pain ratings through the visual analog scale, differences between groups failed to reach significance. Despite distinct techniques, individuals

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reported roughly comparable levels of discomfort following the procedure. Much like the results observed by Bisher et al (11), where both single drill and standard drilling produced similar subjective pain reports, this study aligns closely. Recovery progression appears unaffected even when reducing the number of drilling steps involved. Healing timelines stay consistent regardless of procedural simplification applied earlier**.**

One reason the single-drill approach performs better in early implant stability seems tied to reduced bone removal. This tighter fit probably increases contact between implant and surrounding bone, improving stability. Fewer drilling steps may also mean less micro-damage occurs nearby. Healthier local bone could result from such an updated process. Noticeably higher stability numbers support this idea**.**

Nadine Marheineche and her team(12),along with Senada et al.(6), plus Ahmed et al. (13), noticed stronger initial stability using single drill method. Since the single-drill approach creates a marginally smaller socket, more pressure builds during screw-in, boosting grip through tighter bone contact. Even so, Tabassum and colleagues.(14),warned that too much squeezing risks harming early regeneration - once natural remodeling capacity is surpassed**.**

Bone adaptation following placement contributed to improved stability in both sets of implants over time. Following recovery, measurable gains emerged across the board, pointing to natural integration processes at work. Instead of sharp contrasts, results lined up closely despite one method showing marginally stronger numbers. The small gap did not amount to meaningful distinction when analyzed. Healing outcomes imply similar support capacity regardless of drill approach used. What matters seems less about tool choice and more about how bone responds during rest**.**

Though subtle, changes at the ridge level stayed under half a millimeter across both approaches six months post-op. One method didn’t outperform the other in preserving bone height near the implant edge. Minimal shifts occurred regardless of whether surgeons used a single drill or conventional drill technique. Cooling was consistent.

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Torque during placement remained steady. Under such conditions, how the socket gets shaped seems to matter less than expected early on**.**

Notably, bone changes on different sides showed clear differences - loss stood out most along the buccal surface. That side lost more tissue than mesial, lingual or distal surfaces. One reason could lie in its structure: that area often has thinner buccal cortical plates. Blood flow there also tends to be lower. On top of that, daily forces during chewing add pressure, especially after surgery. Earlier work by Spray et al.(15), found alike results - the thinnest buccal walls reshaped fastest if less than 1.5–2 millimeters thick. When remodeling happen, they might simply reflect how bone adjusts naturally under load and blood supply limits - not poor drill methods**.**

Minimal bone loss at the margin appeared in the single-drill approach, much like what occurs using conventional drilling methods. Confirming this, cutting down on drill stages while speeding up site preparation still kept crestal bone levels stable around implant. Similar outcomes emerged in studies led by Guazzi and Bisher.(5, 11), where single drilling showed no downside compared to conventional drilling technique. The pattern holds - fewer steps did not weaken early structural support.

Bone thickness must be evaluated thoroughly before surgery because mistakes can undermine results over time. When implants sit correctly in three dimensions, they support better function and appearance. Proper placement depends on precise planning early in the process. Stability at the crestal bone lasts longer if setup is done right from the start**.**

Conclusion:-

Even with limitations present in this study, positive outcomes appeared using both approaches - no implants failed during the observation period. Cutting down to single drill method shortened surgery time clearly, while still allowing solid integration and good surrounding bone condition. Instead of showing contrasts, the two methods looked much alike when comparing patient discomfort after surgery or changes in crestal bone around the implant. So long as conditions match those tested here, doing without

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conventional drilling method may stand as a practical substitute for traditional layer-by-layer preparation in back upper jaw placements.

Limitations and Recommendations: -

This work carries some limits to keep in mind when looking at findings. Few individuals took part, which may reduce how far results can be stretched. Only a short period was observed, focusing just on early implant stability and bone remodeling. Most analysis centered on regions where bone is weaker - especially posterior maxilla. Future efforts could gain strength by including larger groups, longer follow-ups, or different kinds of bone tissue to check if outcomes still stand**.**

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Table legends:-

Table (1): Demographic data of the study population.

Table (2): Drilling time among studied groups.

Figure legends:

Fig 1. Study flowchart.

Fig. 2 Group I (Single drill). **(A)**Elevation of a full-thickness mucoperiosteal flap **(B)**Drilling through the surgical guide**(C)**Primary stability measurement by osstell(ISQ) (**D)**Cover screw placement **(E)**2nd stability measurement by osstell (ISQ) **(F)**Fixation of screw retained crown by ratchet **(G)**Final prosthetic buccal view**(H)**Final prosthetic occlusal view **(I)**Panoramic view of CBCT.**(J)**Cross sectional view of CBCT**.**

Fig. 3 Group II (conventional drills). **(A)**Elevation of a full-thickness mucoperiosteal flap **(B)**Drilling through the surgical guide**(C)**Primary stability measurement by osstell(ISQ) (**D)**Cover screw placement **(E)**2nd stability measurement by osstell (ISQ) **(F)**Fixation of screw retained crown by ratchet **(G)**Final prosthetic buccal view**(H)**Final prosthetic occlusal view **(I)**Panoramic view of CBCT.**(J)**Cross sectional view of CBCT**.**

Graph.1: Postoperative pain scores (VAS) at different time intervals (Day 0, Day 3, Day 7, and Day 14) in the single-drill and conventional drilling groups. Pain levels showed a significant reduction over time in both groups ($P < 0.001$), with no statistically significant difference between the two groups at any time point ($P > 0.05$).

Graph.2: Comparison of implant stability quotient (ISQ) values at implant placement (primary stability) and after four months (secondary stability) in the single-drill and conventional drilling groups. The single-drill group demonstrated higher primary stability, while both groups showed a significant increase in stability after the healing period, with no statistically significant difference between them.

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Graph.3: Marginal bone loss (mm) at different implant surfaces (mesial, distal, buccal, and lingual) in the single-drill and conventional drilling groups. The buccal surface exhibited higher bone loss values in both groups. However, no statistically significant differences were observed between the two groups at any implant surface (P > 0.05).

Table 1:- Demographic data of the study population:

Demographic data	Group I (single drills) (N=10)	Group II (conventional drills) (N=10)	Test of significance
Age (years) **Mean ±SD** **Range (years)**	37.90±3.28 (26-48)	38.70±2.83 (22-43)	t=0.58 P=0.56
Sex N (%) **Male** **Female**	 5 (50) 5 (50)	 6 (60) 4 (40)	 χ^2=0.20 P=0.65

Data are presented as mean ± SD or number (%). t: Independent samples t-test; χ^2: Chi-square test

Table 2:- Drilling time among studied groups:

	Group I (single drills) (N=10)	Group II (conventional drills) (N=10)	Test of significance
Operative time (min) **Mean ±SD**	0.493±0.011	1.49 ±0.041	t = 74.0 P<0.001*

*$\bar{X}$: Mean; SD: Standard deviation; t: Independent samples t-test *P is significant at 5% level of significance.*

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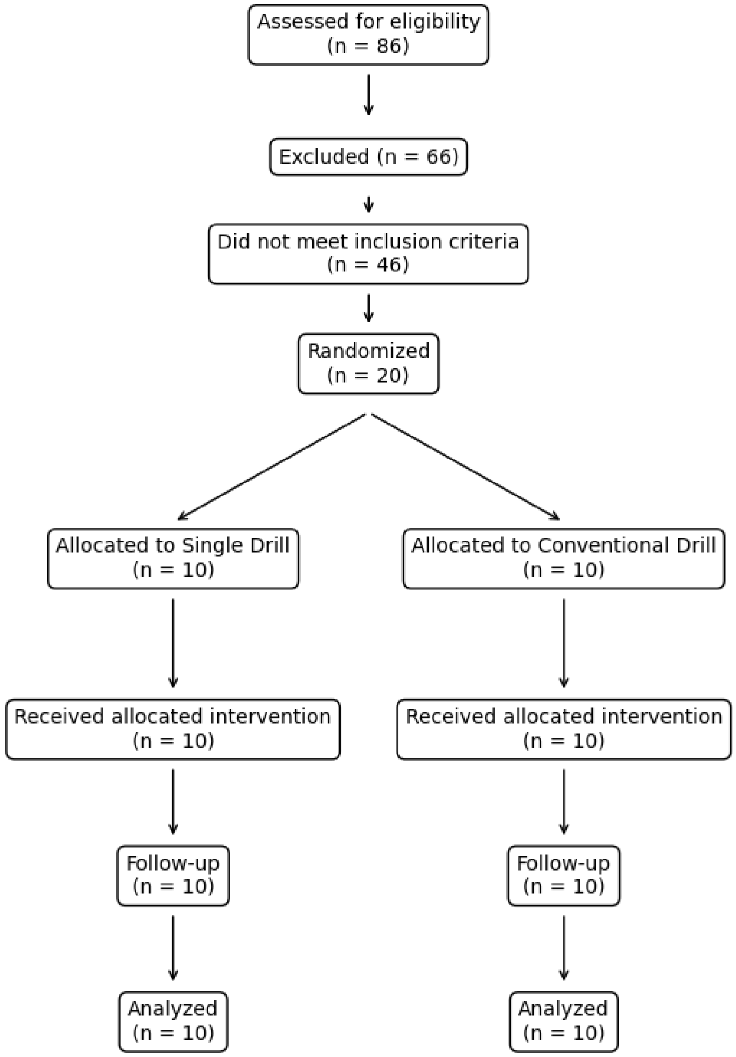


Fig.1:- Study flowchart.

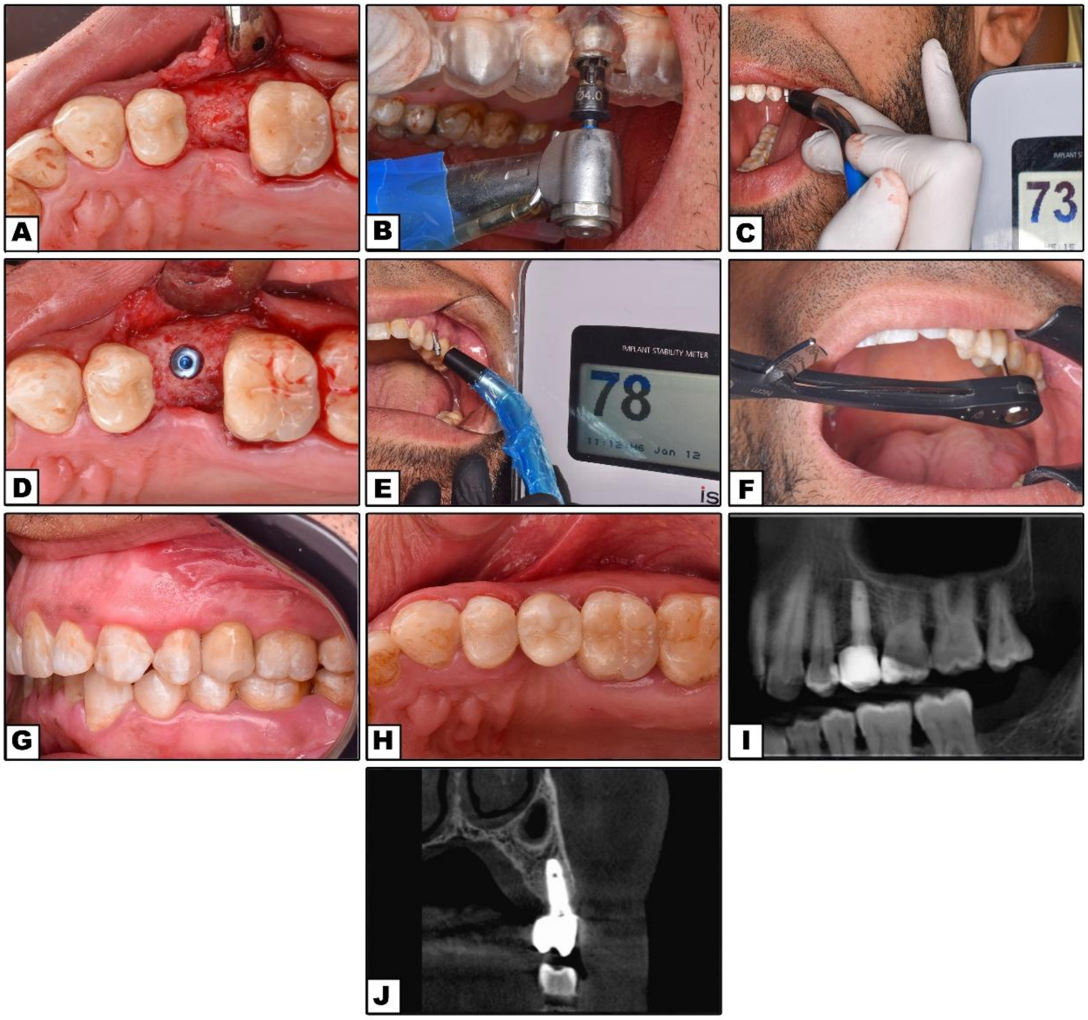


Fig.2:-Group I (Single drill). (A)Elevation of a full-thickness mucoperiosteal flap (B) Drilling through the surgical guide (C) Primary stability measurement by osstell (ISQ) (D) Cover screw placement (E) 2nd stability measurement by osstell (ISQ) (F) Fixation of screw retained crown by ratchet (G) Final prosthetic buccal view (H) Final prosthetic occlusal view (I)Panoramic view of CBCT. (J)Cross sectional view of CBCT.

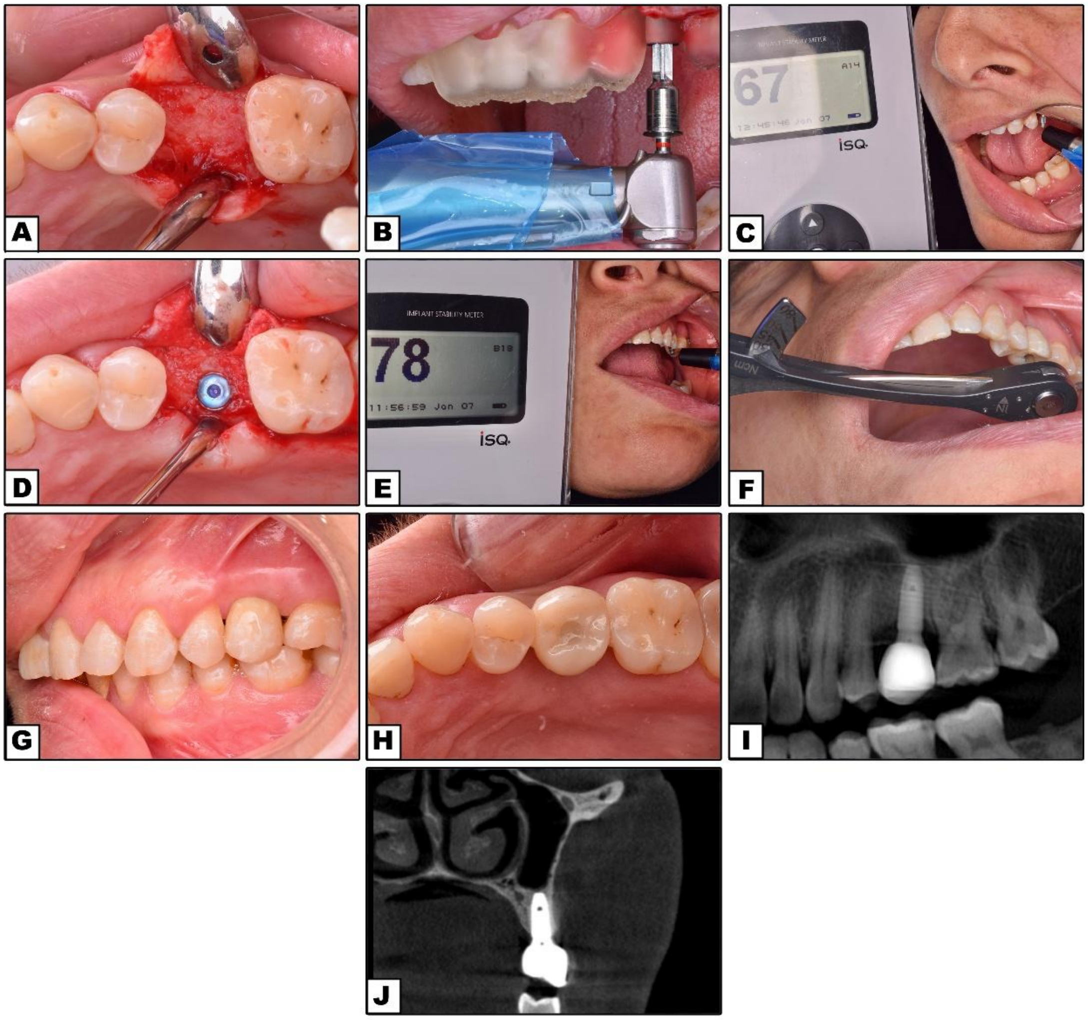
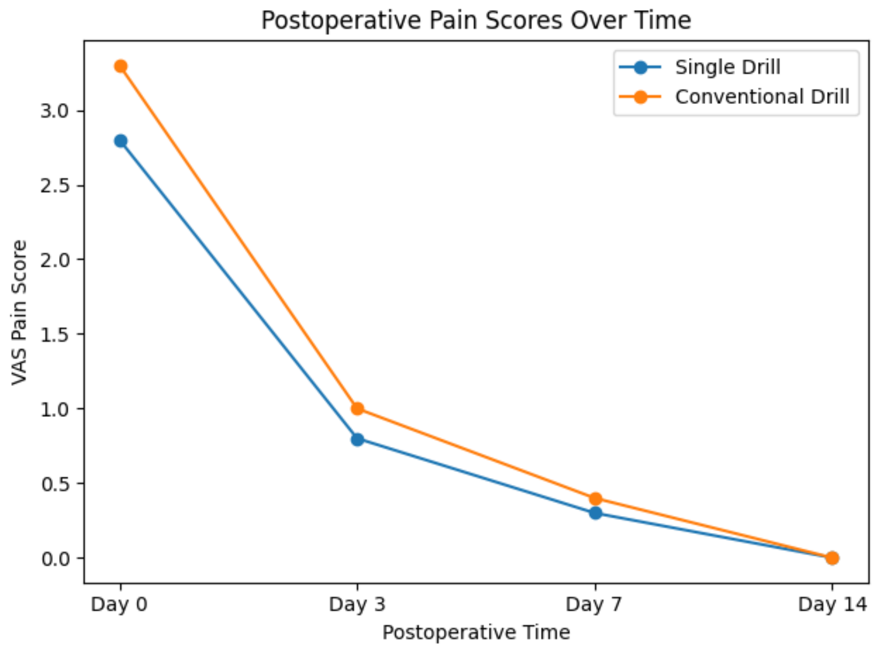
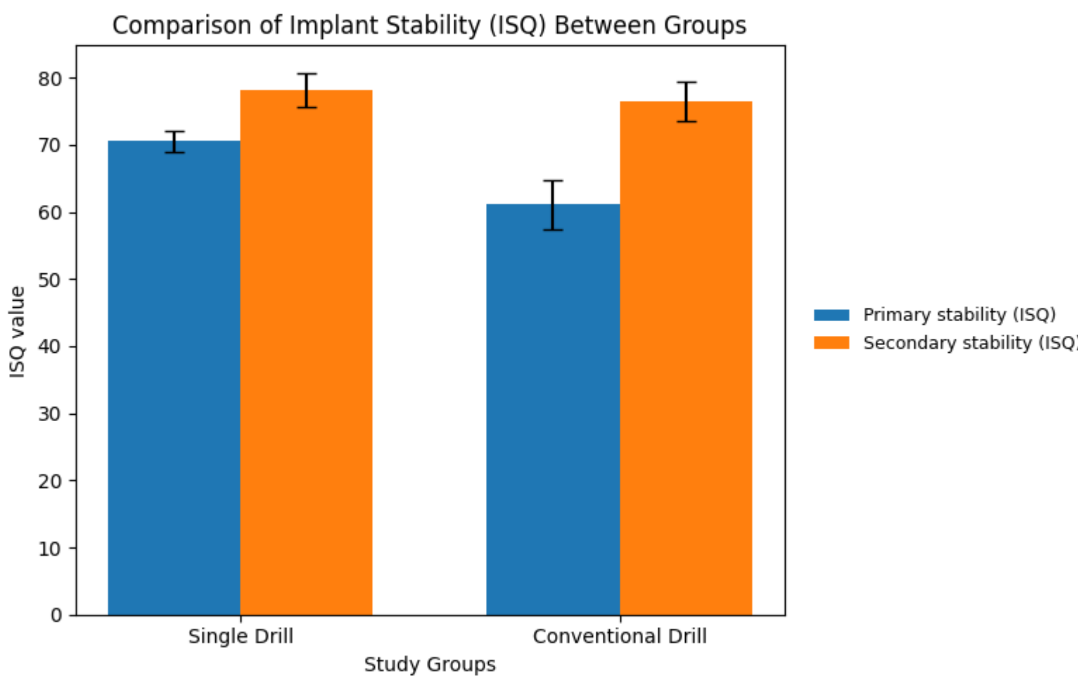


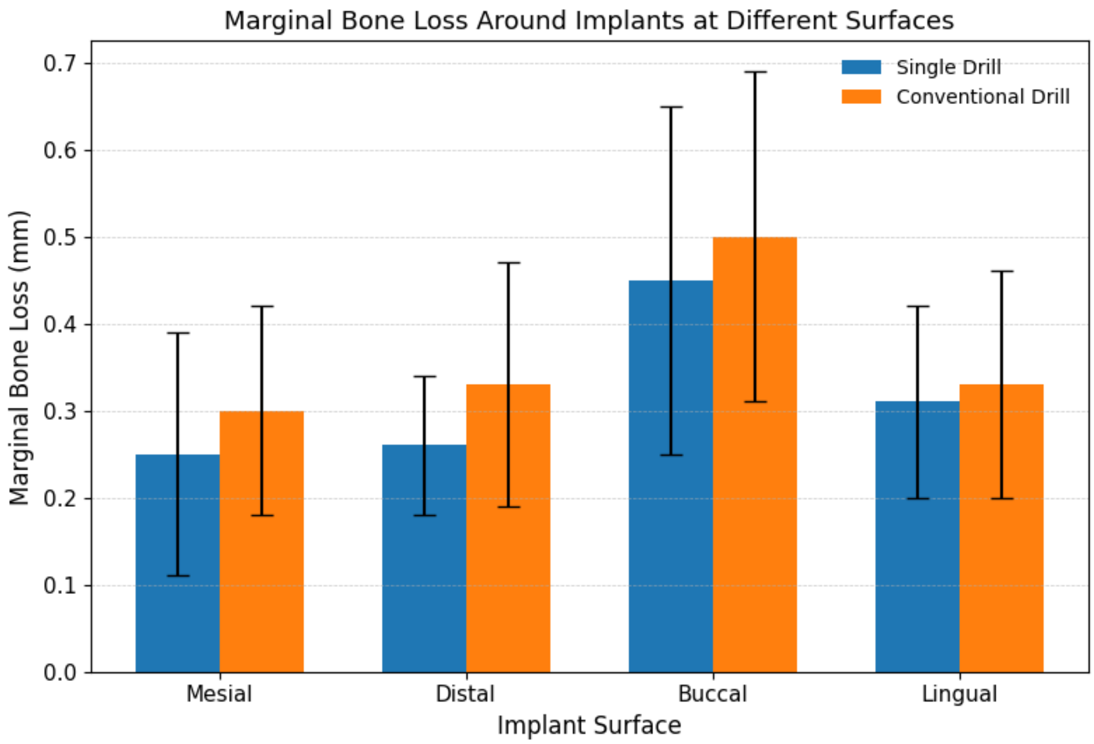
Fig.3:-Group II (conventional drills). (A)Elevation of a full-thickness mucoperiosteal flap (B) Drilling through the surgical guide (C) Primary stability measurement by osstell (ISQ) (D) Cover screw placement (E) 2nd stability measurement by osstell (ISQ) (F) Fixation of screw retained crown by ratchet (G) Final prosthetic buccal view (H) Final prosthetic occlusal view (I)Panoramic view of CBCT. (J)Cross sectional view of CBCT.



Graph.1:-Comparison of VAS between observation times for both groups.



Graph.2:- Comparison of ISQ between observation times for both groups.



Graph.3: -Marginal bone loss (mm) at different implant surfaces (MBL) in the singledrill and conventional drilling groups. Error bars represent standard deviation.

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