

Treatment of the Complete Edentulous Atrophic Maxilla: The Tall Tilted Pin Hole Placement Immediate Loading (TTPHIL)-ALL TILT™ Implant Option

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ABSTRACT

Aim: A severely atrophied maxilla presents serious limitations for conventional implant placement and the reconstruction of which requires extensive surgical treatments. This original article presents an overview of this evidence-based technique used for maxillary rehabilitation.

Background: Growing patients' needs to regain proper oral function with limited surgical effort presents a challenge to the surgeon for implant placement in harmony with the planned prosthesis. Different techniques and protocols have been put forward through the ages to improve implant survival, osseointegration, and quality of life. A new technique—Tall Tilted Pin Hole Immediate Loading (TTPHIL-ALL TILT™ technique)—utilizes angulated long bicortical tapered implants placed in a flapless way in immediate loading with screw-retained prosthetic solutions.

Technique: TTPHIL-ALL TILT™ technique involves flapless subcrestal bicortical placement of a total of six tall threaded tilted implants engaging the nasal cortex and the pterygoid pillars, rigidly splinted maintaining adequate anteroposterior spread, achieving proper primary stability, fit for immediate loading. Screw-retained prosthetic solutions are provided with the elimination of distal cantilever.

Conclusion: The TTPHIL-ALL TILT™ technique can facilitate surgical rehabilitation of patients with maxillary resorption, as an alternative to other graft less and grafting procedures.

Clinical significance: TTPHIL-ALL TILT™ technique provides a graftless solution for the challenging resorbed maxillary edentulous ridges. By following this protocol, primary stability is achieved which gives way for immediate loading satisfying the patient's functional and aesthetic needs.

Keywords: Atrophic edentulous maxilla, Bicortical engagement, Immediate loading, Tilted implants.

The Journal of Contemporary Dental Practice (2019); 10.5005/jp-journals-10024-2592

BACKGROUND

Restorative services for the elderly have been a growing demand through the ages to the dental profession. The elderly affected by edentulousness feel handicapped due to various reasons such as reduced chewing efficiency, difficulty in speech, and poor facial aesthetics leading to low self-confidence at social platforms.^{1,2} There has been an immense increase in the life expectancy in the past decade, thus, demanding the quality of life in these latter years. Implant dentistry has overcome the challenges of the anatomic, aesthetic, and psychological consequences of edentulousness and has been recognized as a successful predictable rehabilitation option. Due to the awareness and increasing demands of providing the best quality of life, continued research, diagnostic tools, treatment planning, implant designs' materials, and techniques have been evolving to succeed even in the most challenging clinical situations.³

The discovery of osseointegration by Branemark in 1986 brought out the revolution.⁴ With sufficient quantity and quality of bone being present, osseointegration was possible with dental implants. However, as a result of loss of teeth, due to lack of stimulation to the residual bone, there is a reduction in the bony ridge volume as a part of the physiological process.⁵ Removable denture retention is compromised due to the same phenomena and the bone loss is rather accelerated. Inadequate bone volume can also be the result of resorption following extraction, trauma, infection, and pneumatization of the maxillary sinus.⁶ To improve the volume for the benefit of osseointegration process, grafting solutions have been in use with methods like autogenous bone grafts, guided bone regeneration, allogeneic material, and combinations of these

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How to cite this article: Nag PVR, Dhara V, *et al.* Treatment of the Complete Edentulous Atrophic Maxilla: The Tall Tilted Pin Hole Placement Immediate Loading (TTPHIL)-ALL TILT™ Implant Option. *J Contemp Dent Pract* 2019;20(6):754–763.

Source of support: Nil

Conflict of interest: None

procedures with delayed loading.⁷ Areas of interest included grafting to the floor of the nose and the maxillary sinuses, and interpositional bone grafting in conjunction with a Le Fort I procedure.^{8–11}

The complications, morbidity, and increasing costs associated with these procedures or grafts demanded graftless alternative solutions with immediate rehabilitation.^{12–14}

The above-mentioned reasons drove a paradigm shift in implant dentistry toward treatment concepts, designs, and protocols like immediate loading, tapered surface-treated implants, basal implantology, All-on-4 treatment concept, zygomatic implants, pterygoid implants, etc.^{15–18}

Conventional crestal implants require ridge augmentations or sinus direct or indirect lifts for placement and are severely limited

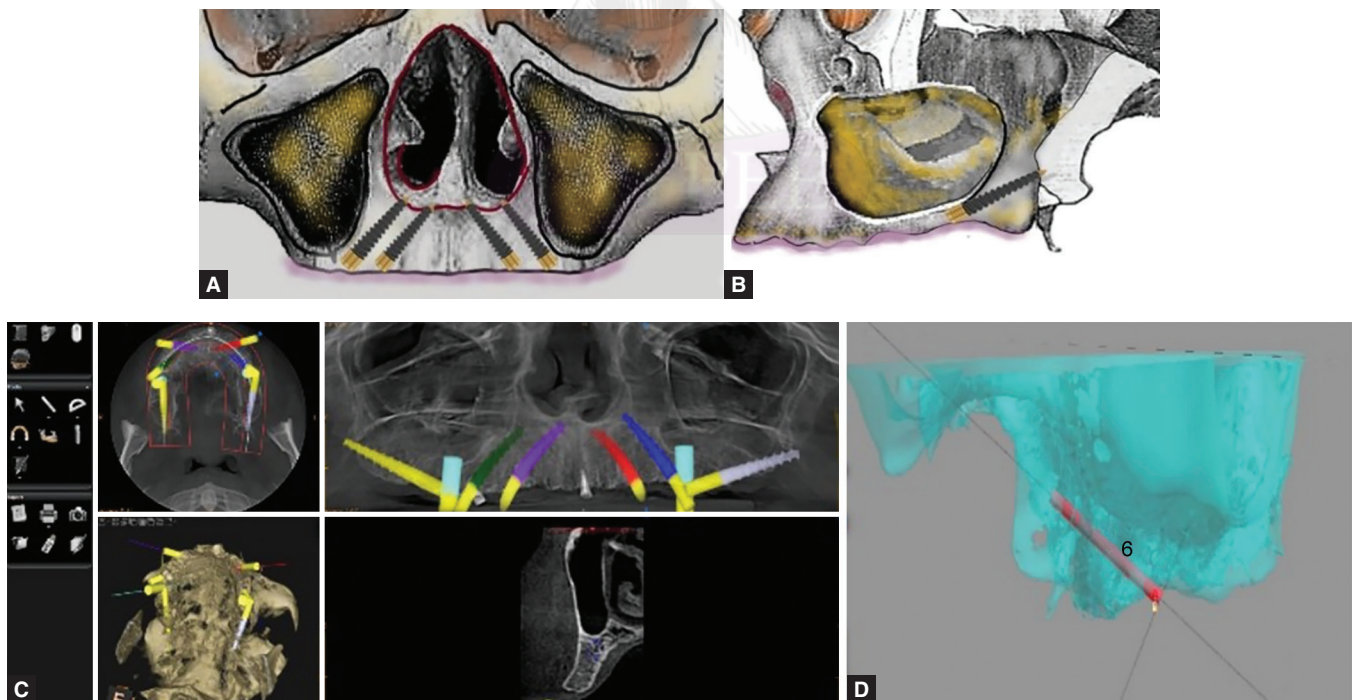
when it comes to the resorbed maxilla.¹⁹ Basal implantology which is based on employing the basal cortical portion of jaws for implant retention (orthopedic principles) has been used extensively in resorbed ridges.^{20,21} The design of the implant used in this protocol has a vertical shaft and a united implant abutment with a screw apex. This shaft connected to the basal disk is elastic and can be bent by 15–45°. On immediate loading, the continuous functional loads remodel the bone which adapts over the implant. Two schools of thoughts have been followed: the multi-implant concept of French school and the strategic implant positioning concept of German school with fairly successful outcomes.²² However, there are limitations in the implant design, surgical technique, prosthetic phase, and the maintenance phase. This technique-sensitive procedure may cause functional overload osteolysis and fracture of the implant due to its design.²³ It is also restricted to severely resorbed ridges, thus, requiring multiple implants. In failed cases, retrieval of the implant is very cumbersome compromising the bone.²⁴

The revolutionary All-on-4 concept introduced by Paulo Malo (1996) followed the insertion of straight and tilted implants between two cortical layers. The increased bone to implant contact provided improved primary anchorage. It has been universally accepted with high success rates.^{25,26} Its use, however, is restricted by the shorter lengths of implants used, open flap procedures, limited success in immediate loading, short arch cantilever loads, expensive Malo bridge as a part of implant design, surgical technique, prosthetic, and maintenance issues.^{27–29}

Branemark came up with another alternative for rehabilitation of severely atrophied ridges: zygomatic implants. These were a boon especially in cases of oncological resected maxilla greatly reducing the number and size of grafting procedures and implants used via predictable posterior anchorage.³⁰ The design of the implant was specifically modified per the requirements with good clinical performance, although the invasiveness of the procedure and the

morbidity associated with it like sinusitis, oroantral fistula formation, orbital penetration and injury, nerve deficits, surgical edema, etc. limit the use of zygoma implants in all cases. Additionally, the load of distal cantilever and the requisite for delayed loading in zygoma cases are considered as other disadvantages.³¹

The Tall Tilted Pin Hole Immediate Loading (TTPHIL) concept has evolved from various ideologies in implantology: basal, pterygoid, and angulated/tilted implants under immediate loading. In the conventional implant techniques, the distribution of prosthetic loads to the bone–implant interface, poor bone density, and added restorations may pose an important risk factor for the long-term survival. To maximize the success of rehabilitation, the TTPHIL technique utilizes the use of long tilted bicortical implants. Longer implants have more bone to implant contact, thus, improving osseointegration. By engaging the alveolar and nasal cortex, hard tissue augmentation procedures and vital structures in the premaxilla are avoided.^{32–34} In the posterior maxilla, pterygoid implants are placed. Pterygoid implants were introduced by Tulasne which were intended to pass through maxillary tuberosity, the pyramidal process of palatine bone and engaging the pterygoid process of sphenoid bone.^{35–37} It overcomes the need for sinus lift procedures, grafting process, and, at times, even the invasive zygoma implants. The success rates of tilted and pterygoid implants for maxillary rehabilitation have been more than 98% and 94%–99% as documented in the literature, respectively. Engagement of basal bicortical bone is done which is highly mineralized and least resistant to resorption for achieving good torque. Bicortical engagement of implants has proven to achieve better stabilization with less stresses on the crestal bone and implants. The use of flapless approach for this technique offers the possibility of placing implants in less time without tissue trauma due to flap reflection and reduced postoperative discomfort.^{38,39} It also has the advantage of maintaining the soft tissue profile not compromising mucointegration and osseointegration⁴⁰ (Figs 1A and B).



Figs 1A to D: (A and B) Flapless placement of long tilted implants engaging cortical bone of nasal cortex in the premaxilla and the pterygoid plate in the atrophic posterior maxillary region; (C) Cone beam computed tomography (CBCT) data for surgical planning of six tilted implants; (D) Final placement (point of entry and exit)

Table 1: Table highlighting key features of TTPHIL-ALL TILT™ technique

Mucointegration—one time abutment concept ⁴¹
Single-drill under preparation ^{42,43}
Self-drilling active threaded implant for bicortical basal bone engagement ⁴⁴
Tall implants to engage cortical plates (16–57 mm) ^{45–47}
Tilted implants (15–65°) to have more bone implant contact ^{48,49}
Rigid splinting with screw-retained solution for retrievability ⁵⁰
Platform switching abutment with no micromovement at implant abutment junction ⁵¹
Flapless subcrestal placement (pin hole procedure) ⁵²
Immediate prosthesis within 3 days to a week time

The TTPHIL protocol improves force distribution through increased anteroposterior spread, increased implant length in less bone, apical fixation in basal bone, and bypasses sinus; avoids bone grafting; reduces implant number (only six implants) achieving good insertion torque—for immediate function with rigid splinting; and allows engagement of dense bone with no crestal bone loss. On the prosthetic front, screw-retained solutions are provided by multiunit abutments and use of open tray impression techniques for fabrication of rigid prosthesis. Better prosthesis hygiene maintenance is an added virtue. Thus, the TTPHIL-ALL TILT™ technique, even though is a novel approach to placement of implants, is derived from established schools of thought in implantology through the ages. The highlights of TTPHIL-ALL TILT™ are tabulated (Table 1).

CLINICAL TECHNIQUE: THE TTPHIL-ALL TILT™ PROTOCOL

Preoperative Workup

As TTPHIL-ALL TILT™ technique is a flapless single-drill placement of implants, a thorough radiographic evaluation of the prospective patient's jaws is indicated. These studies include panoramic films, CBCT for digital planning, and fabrication of stereolithography models and surgical guides. The dicom image files are converted to STL files on which the surgical planning is done using specific software (BlueSkyPlan, United States). Studies are done to evaluate bone density and to identify anatomical structures: maintaining adequate safety distance from the palatine neurovascular bundle, inferior maxillary artery and the pterygoid plexus, distance from alveolar ridge to apical portion of the pterygoid apophysis and the nasal cortex, anterior and posterior walls of maxillary sinus, etc. The ideal angulation and the length of the implant in the sagittal view and coronal view and the point of entry (Point A) and exit (Point B) of the implants are also marked (keeping in mind the borders of the maxillary sinus) which are then reproduced onto the stereolith model. In this way, planning and data transfer occur with a goal of transferring the same to the patient for clinical benefit (Figs 1C and D).

The fabricated stereolith model is used to study the anatomy specific to the patient, with the point of insertion and exit of the implant marked per the virtual planning. These models can be used for mock surgery, patient education, and fabrication of surgical templates. The surgical guides are incorporated with sleeves to guide the direction of the drill while performing the surgery or a metal guide template with a central pin that can be used on which the point of entry and angulation of the drill or implant are marked or transferred per the plan from the stereolith model (Fig. 2A).

Indications

- All cases of edentulism, even in resorbed posterior maxilla.
- Immediate loading cases, where avoiding cantilever is necessary, rescue option in grafting failures, aid in zygoma implants, and short implants.
- Patients, in whom grafting procedures or zygomatic implants would be morbid or medical conditions wherein such invasive surgical procedures are contraindicated that can undergo the TTPHIL technique.

Contraindications

Severely debilitating systemic disease. Consideration needs to be given to the mouth opening of the patient, enough to access posterior regions.

Surgical Technique

Armamentarium

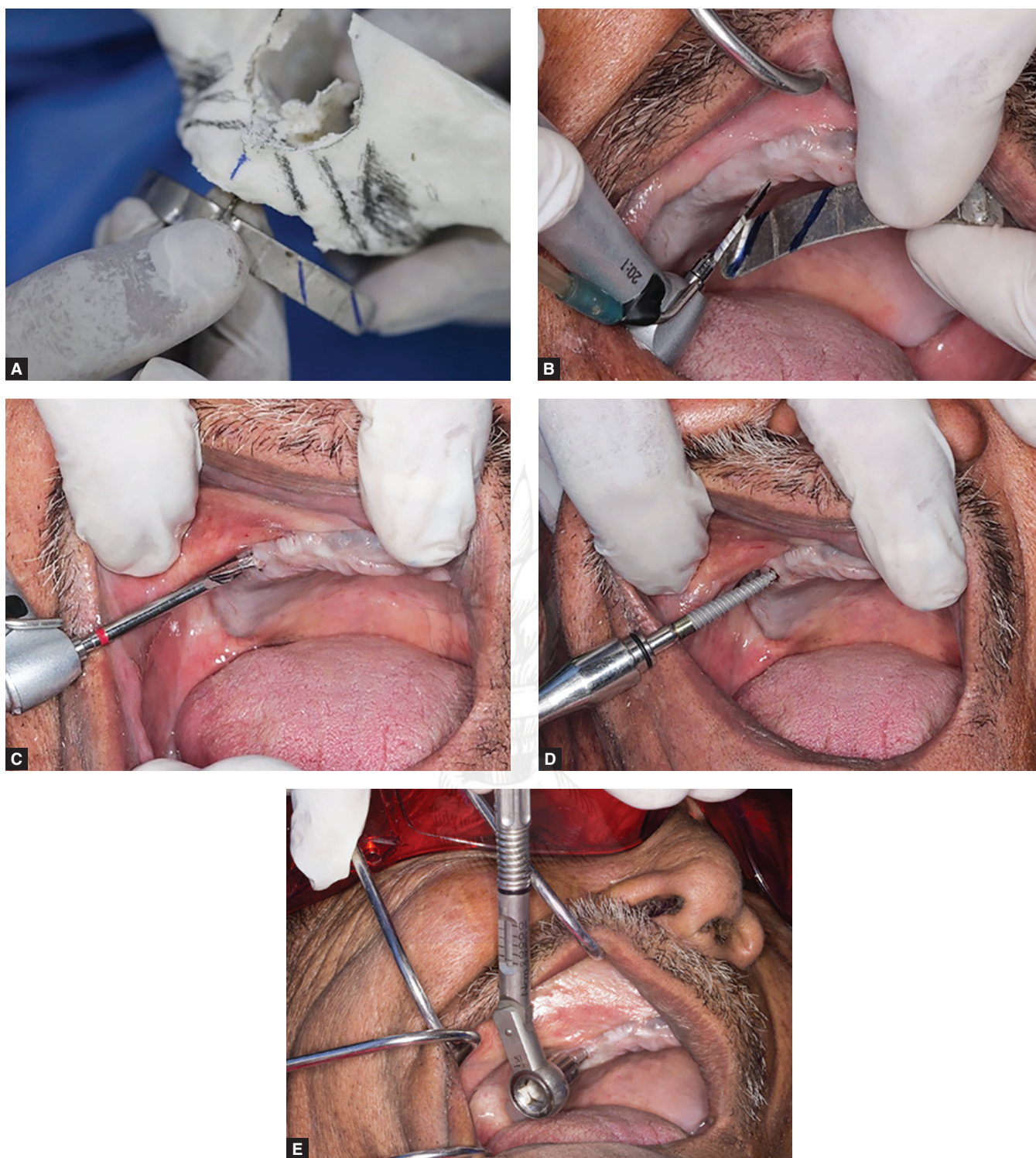
The armamentarium includes the following: diagnostic instruments, surgical instruments, physiodispenser unit, drill kit-pilot drill, short & long drills, stepped osteotomy drill, hex drivers, surgical guide, or ALL TILT metal template.

Under aseptic precautions (flapless approach), crestal anesthesia is given at the planned surgical sites. The ALL-TILT metal template on which the pilot drill entry is marked using the stereolith is placed intraorally against the alveolar ridge with the central pin anchored at the midline (Fig. 2B). The first anterior implant is placed anterior to the maxillary sinus wall (entry point at the junction of the floor of the maxillary sinus and anterior wall).

The pilot drill of 1.2 mm is inserted through the mucosa into the alveolar bone using the metal template as a guide for the point of entry to a depth of 6 mm, perforating the crestal cortical plate. A portable radiovisiography (RVG) is taken to visualize the direction of the drill into the bone and its relation to the anatomic structures, especially the sinus walls and also to check mesiodistal tilt of the initial drill. The limited initial entry into the cortex is of the importance that the direction of the drill could be changed if placed incorrect, after confirmation with the RVG, without widening the osteotomy. The surgical guide improves the precision of the drills in the planned directions when used.

Once satisfied, drilling continues with the template or the guide in place, until the required cortical engagement is reached. It is vital that the physiodispersing unit is run at lower speeds of 400–600 rpm for a better tactile feel or proprioception of the drill as it enters the cortical plate (nasal). The single-drill concept is followed, i.e., long stepped drill with a diameter of 1.4–2.2 mm is used with enough coolant (Fig. 2C). Under-drilling, wherein the diameter of the drill is less than the implant to be placed for better anchorage, is done. The direction of the drill would be distal to mesial, toward the nasal cortex. It is vital that the operator's finger is placed along the palatal and labial/buccal aspects of the ridge while drilling and placement of implant so as to rule out the drill or implant placement beyond the buccal or palatal walls.

A depth gauge is then used, placed inside the channel to assess and finalize the length of the implant by using a check X-ray. The selected implant (tapered 3.75 mm or 3.5 mm diameter with a length of 18 mm or 20 mm or 22 mm) is then mounted on the implant driver and driven into the channel slowly until it engages the nasal cortex. The concept of osseodensification occurs, i.e., the expansion of cortex while insertion (Fig. 2D). Torque ratchet is used for the final placement and the resistance of the implant is



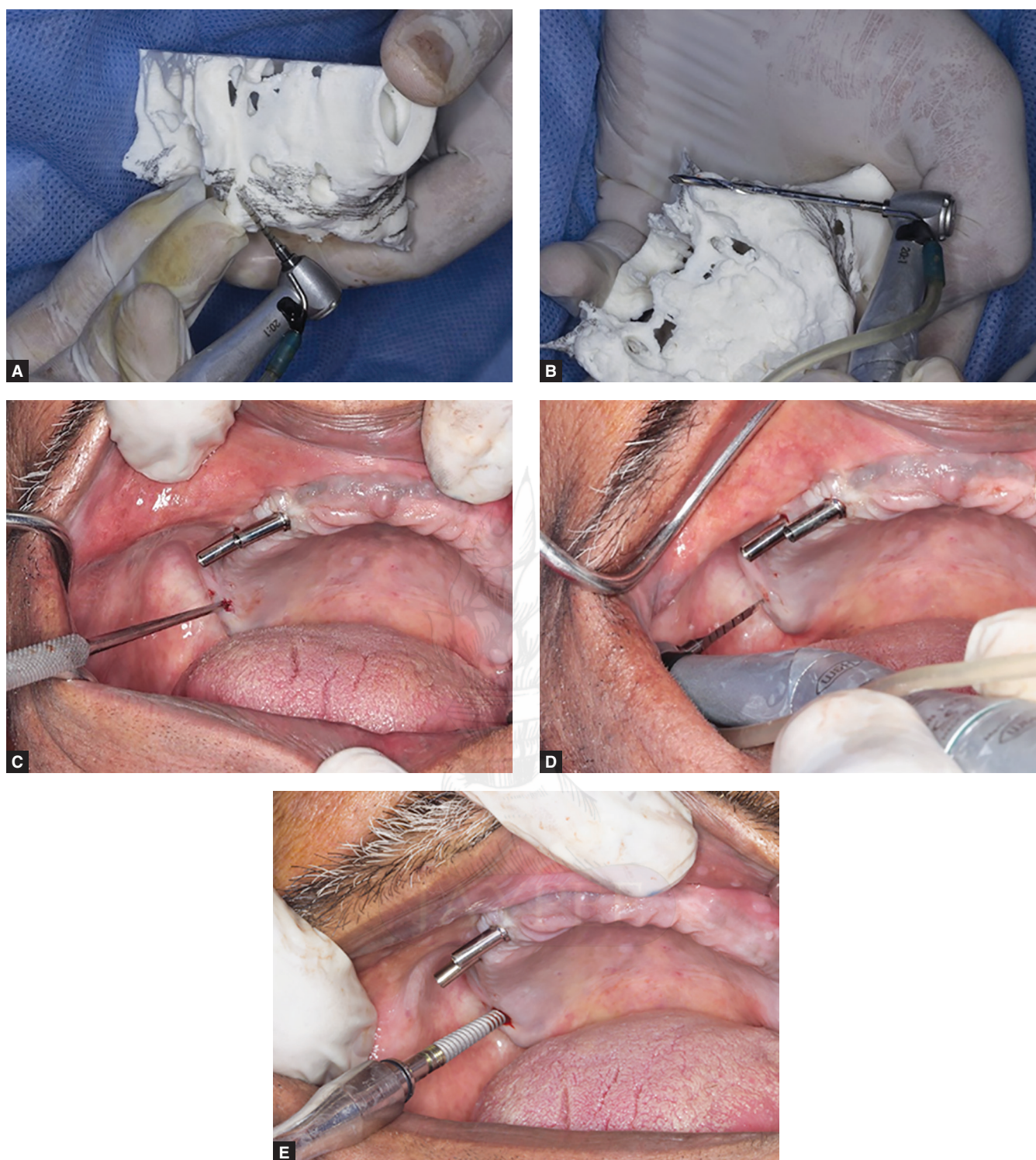
Figs 2A to E: (A) ALL TILT metal template and surgical guide on the stereolith model; (B) Point of entry for the anterior implant; (C) Single-drill concept; (D) Implant fixture placement; (E) Torque ratchet for primary stability

checked against torque and reverse torque forces of 30–50 N cm. The primary stability of the implant is, thus, checked with the torque test to determine the loading protocol (Fig. 2E).

A post-insertion X-ray of the implant should be taken for the final assessment. The next drill-implant fixture placement is done parallel to the first anterior implant which engages the nasal cortex using the surgical guide, followed by a check RVG.

For the placement of the pterygoid implant (preferred a length of 22 or 25 mm), adequate crestal anesthesia at the planned surgical site is injected (Figs 3A and B). A pterygoid instrument is inserted and a check RVG is taken to confirm the point of entry (junction of the floor and posterior wall of maxillary sinus) and the initial path (Fig. 3C).

Using a physiodispenser speed at 400 rpm, the pilot drill is used next, and after palpation of the hamular process, it is directed 5 mm



Figs 3A to E: (A) Planned direction of pterygoid drill mesial to distal; (B) Buccal to palatal; (C) Use of pterygoid instrument; (D) Pilot drill for pterygoid implant; (E) Implant fixture placement

laterally at approximately 45° to the occlusal plane. This process is a guide to identify the thickest part of the pterygoid pillar of the bone. The single stepped drill encounters dense cortical bone of the pterygomaxillary suture area at 10–14 mm deep. Just after crossing the pterygoid process, the drill is stopped. The direction followed is mesial to distal and buccal to palatal (Fig. 3D). A depth gauge is

again used and a check X-ray is taken to finalize the length of the implant and to ensure its path without perforating the posterior wall of maxillary sinus.

The implant is now driven slowly using the implant mount with a long handle until subcrestal placement is achieved (Fig. 3E). A torque and reverse torque test will determine the primary stability

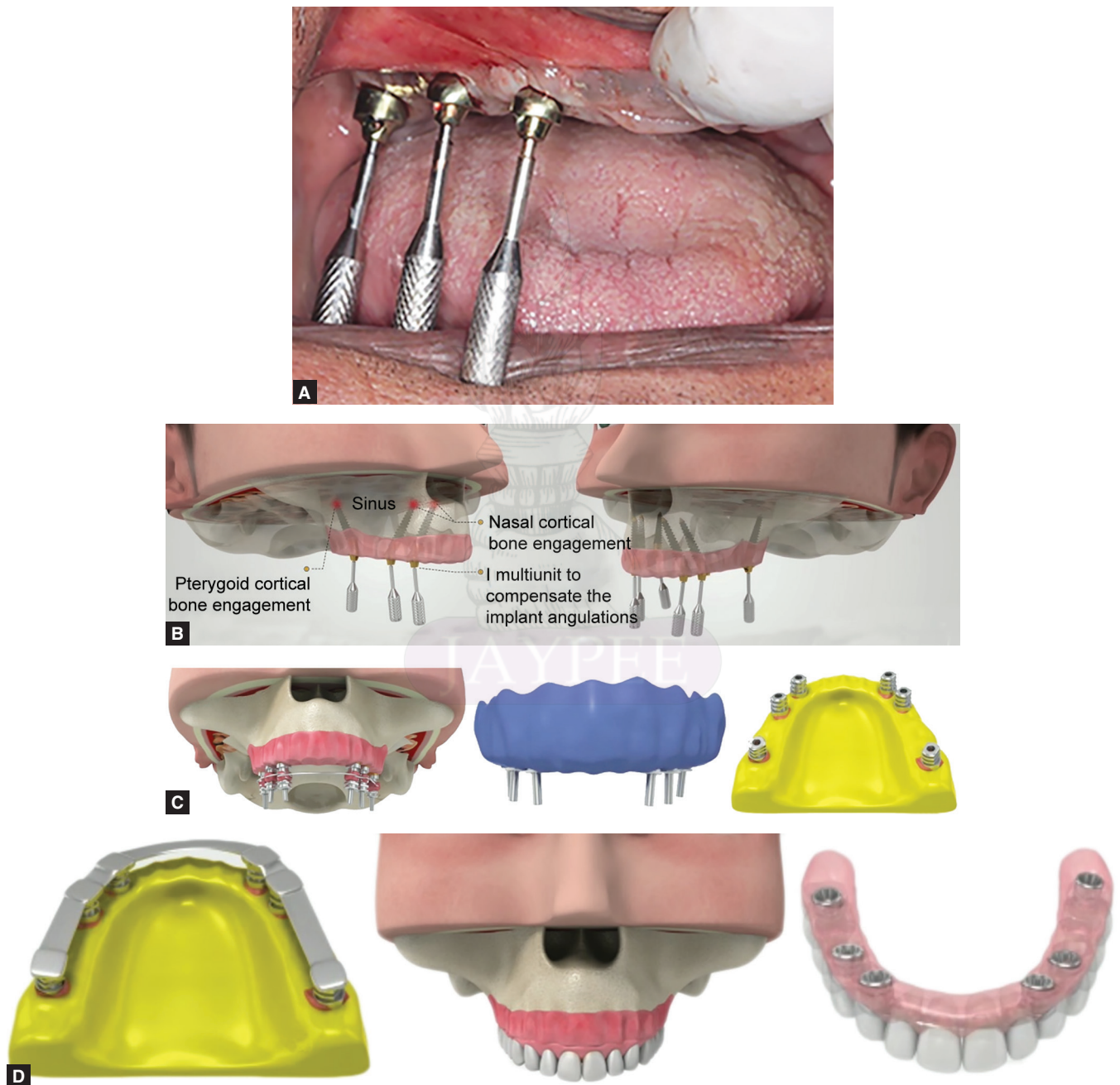
of the pterygoid implant, thus, preparing for immediate loading (preferred torque $>35\text{--}45\text{ N cm}$).

The same procedure of placement of the three implants is done on the other side. Multiunit abutments (30° , 40° , and 50°) are then placed at the correct angulations to compensate for the tilt of the implants (Fig. 4A). The surgical phase is followed by the prosthetic phase of impression making with transfer copings, Jig trial, bite records, metal framework trial, bisque trial followed by placement of final prosthesis using computer aided design and computer aided manufacturing (CAD CAM) technology for design, and fabrication

within 2–5 days (Figs 4B to D). Post-placement orthopantomogram is taken (Fig. 5). Presurgical clinical picture and postfixation of final prosthesis of patient treated with TTPHIL-ALL TILT™ are shown in Figures 6A and B.

Follow up

In the postoperative and follow-up period, patients are advised to adhere to strict soft diet regimen with oral hygiene maintenance. The patients can be recalled after 1 month, 3 months, 6 months, and 1 year for clinical and radiographic assessment.



Figs 4A to D: (A) Placement of multiunits to compensate for angulations; (B) Position of implants with multiunits placed; (C) Open tray impression copings splinted, direct pick up impression was taken and cast with copings; (D) Rigid splinting, fixation of screw-retained prosthesis and maxillary permanent prosthesis



Fig. 5: Orthopantomogram showing rehabilitation in edentulous ridges using TTPHIL-ALL TILT™ technique



Figs 6A and B: (A) Presurgical clinical picture; (B) Postfixation of final prosthesis

DISCUSSION

Treatment of edentulousness has always been a challenge to the field of implant dentistry. Continuing resorption of bone, poor density in the maxillary posterior ridges, systemic conditions limiting placement, increasing demands of patients, and growing edentulous population have boosted the field of research and

development in implant dentistry. The original Branemark protocol in 1985 suggested an implant fixture placement 12 months after extraction, with uncovering procedure and abutment placement in the next 4 months and finally functional loading at the end of 20 months. The All-on-4 technique, zygoma implants, and basal single-piece implantology have gained popularity by studying and understanding bone physiology, anatomy, biomechanical response to the design and stresses of loads, and longevity of rehabilitation. Each concept has had its fair share of advantages and clinical limitations, however, with good success rates. There are numerous options in the prosthetic phase for implant rehabilitation. The success of implant treatment relies on various prosthetic factors like abutment selection, A-P spread, impression techniques, recording of jaw relations and transfer to laboratory procedures, trials, material of use for the final prosthesis, and the type of fixation, i.e., screw or cement retained. Innumerable research can be found in the literature highlighting the prosthetic techniques used for the corresponding implant design and placement with guidelines. Immediate loading has been the loading protocol in demand by most of the patients. Restorative dentists, surgeons, clinicians, and researchers alike have worked toward making it possible by modifying various micro- and macro-implant designs, implant placement techniques, biomechanical stress patterns, and arch stabilization.

The advantages of each school of thought were studied and analyzed, and, thus, TTPHIL-ALL TILT™ technique was developed.

Poor bone quality at the posterior edentulous ridge areas is due to the increased porous and cancellous bone. Progressive sinus pneumatization and alveolar resorption occur as a result of this tooth loss pattern as seen in Kennedy's classes I and II. The presence of sinus invagination limits the placement of implants. Short implants have failed to achieve longer durability and are associated with limited outcomes. Short implants are of usually 5–8 mm in diameter requiring additional 2–3 mm bone all around, which is not found in most of the resorbed ridges. Additionally, due to the increased crown to implant ratio, vertical cantilever is usually seen. Delayed surgical healing, systemic co morbidities limitations, chances of graft failure, donor site morbidity, and extra treatment expenses are not seen as favorable consequences of grafting procedures by the patients and restorative dentists.

By understanding the anatomy of maxilla and the mechanics of axial, transverse and oblique loads, bicortical stabilization has come into light. The buttress regions of the maxilla include the zygomatic, pterygoid, pyriform, etc., which have been the areas of interest in maxillary rehabilitation. The presence of pterygoid region provides cortical stability to the implant when engaged, as the posterior maxilla is made of poor quality spongy cancellous bone unfit for immediate loading. This option also avoids grafting procedures like direct and indirect sinus lifts as one-stage and two-stage procedures. Even with one-stage procedures, implants have only the crestal cortical engagement, which invariably causes micromotion leading to failures in immediate loading. Similarly, the nasal floor is of cortical nature and has been utilized even in the All-on-4 concept for achieving stable fixation of implants in the premaxilla. The TTPHIL-ALL TILT™ technique was developed as an effort to provide a graftless solution to the resorbed atrophic edentulous maxilla in a noninvasive way taking anchorage of pterygoid, nasal floor and the lateral nasal walls. Tilting of implants is done to avoid the limiting anatomical structures like the maxillary sinus. Success rates of tilted implants in the literature ranged

from 95.7 to 100%,⁵³ which have been enhanced by bicortical engagement.

The All-on-6 implant design is limited in resorbed posterior maxillary edentulous ridges due to sinus pneumatization. By adopting the All-TILT-6 design, 2 tall-tilted implants are placed engaging the pterygoid pillar (junction of the palatine process of maxilla, pyramidal process of palatine bone and pterygoid process of the sphenoid bone), thus, eliminating distal cantilever along with avoiding of sinus encroachment or any other augmentation procedures in the posterior maxilla.

The use of tall implants with bicortical engagement offers a primary stability which is a strong predictor of implant success.⁵⁴ The insertion torque values and implant stability quotients are inclined by the cortical bone contact since bicortical bone anchorage led to a higher insertion torque and higher implant stability quotient.⁴⁵

In the literature, studies have been performed on a two-dimensional finite element analysis to evaluate the effects of implant length and diameter on the stress distribution, and the results observed that an increased implant length results in stress reduction on the implant in both immediate and delayed loading protocols.^{55,56} Long tilted implants (≥ 13 mm) placed in the maxillary arch have been advocated to obtain high levels of initial primary stability, avoiding bone-grafting procedures. This situation may be of extreme importance from the biomechanical standpoint (with the insertion of short-implants, combined with the poor bone quality and exposure to high occlusal loads)^{57,58} and from the clinical standpoint (when rehabilitating maxillary edentulous arches with low-density bone, which represents a frequently cited cause of dental implant treatment failure).^{59,60}

Anchorage from cortical bone of the anterior wall of the sinus and the nasal fossa is possible due to longer implant lengths positioned from the 1st/2nd premolar (the implant apex anchored on the nasal cortical floor).⁴⁶

Additionally, tilting implants can enhance the anterior-posterior spread of the implants to provide satisfactory molar support for a full fixed prosthesis.⁶¹ Tilting of implants reduces the cantilever length and, as a consequence, gives rise to better load distribution.⁶²

Subcrestal implant placement decreases the stress in the crestal cortical bone around dental implants. Placing an implant in a subcrestal position may have a positive impact mainly in the aesthetic areas where obtaining a harmonious emergence profile is mandatory. Apical cortical anchorage can be effective in limiting implant displacement.⁶³ Thus, bicortical anchorage with subcrestal placement is the advantage which TTPHIL-ALL TILT™ concept provides.

Flap surgeries for implant placement with and without grafting affect the soft tissue profile. Flapless guided or non-guided placement aids in mucointegration, with good aesthetic profile and patient satisfaction. Tissue trauma is avoided as implants are placed using surgical guides or stents fabricated via computed tomography data for accuracy.

As discussed above, the biomechanical advantage provided by placing tilted bicortical tall implants in a subcrestal fashion offers superior mechanical stability due to improved osseointegration. Previously, it has been manufacturer-driven implantology, i.e., clinicians were limited by maximum lengths of 16 mm as manufactured by companies, which was not suitable for bicortical anchorage in all cases. Thus, practice-driven implantology now has

evolved the dimensions of implants too due to which taller implants of lengths 15–25 mm have come up. These aid in immediate loading of the prosthesis. Thus, better prosthetic rehabilitation can be achieved satisfying the patient aesthetically and functionally. From a prosthetic point of view, screw-retained prosthesis is provided under this TTPHIL-ALL TILT™ concept. It is said that the choice of retention type may not have a crucial role in the overall survival of the prosthesis but may be responsible for the development of certain complications. They have been shown to be superior to cement-retained counterparts, due to the retrievability option and favorable peri-implant biological profile. With enough stress distribution by six implants and adequate antero-posterior spread, the cantilever is eliminated; thereby reducing the unfavorable compressive strength, greater tensile loads on the medial and distal implant sites.⁶⁴

Thus, TTPHIL implant-prosthetic protocol follows predictable screw-retained solutions with adequate cross arch stabilization via digital CAD CAM technology. Predictable outcome with reparability and easy maintenance and no deleterious cantileverage are the advantages of TTPHIL-ALL TILT™ concept over All-on-4 and All-on-6 concepts.

CONCLUSION

This surgical-prosthetic protocol is a promising rehabilitatory option, as it has been derived from successful predictable solutions in implant dentistry. It can be utilized on a larger scale in the form of prospective studies, highlighting the clinical and biological advantages of distributed stress algorithms with this design and framework.

CLINICAL SIGNIFICANCE

Traditional implantology, i.e., conventional crestal implantology, has limitations when it comes to immediate loading, which is the demand of today by most patients. The TTPHIL-ALL TILT™ technique, an anatomically driven graftless solution, is characterized by the elimination of cantileverage, minimal invasiveness, and screw-retained prosthetic solutions with rigid cross-arch stabilization delivered immediately. This protocol is an amalgamation of evidence-based well-practiced bicortical implantology, tilted implantology with subcrestal placement, and flapless guided implantology presented in a first of its kind novel way to deliver permanent prosthesis in 2–5 days.

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