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Research Paper

Tilted Implants : An Alternative To Conventional Implants For Resorbed Ridges

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Abstract: *Edentulism often results in reduced masticatory ability, esthetic compromise and poor oral health of the patient. Implant placement in resorbed ridges becomes challenging due to insufficient bone quality and quantity & nerve proximation. Sinus lift procedures,nerve transposition and lateralization, ridge splitting and Distraction Osteogenesis may help in compensating the defects but increases the treatment duration and patient morbidity. Hence, angled Implants were introduced to overcome the demerits for implant placement in resorbed ridges, where implants are placed in tilted pattern to avoid interference with anatomical structures. All on Four, Zygomatic and Pterygoid Implants are its types. Two Straight Implants anteriorly and two tilted implants posteriorly were placed in All on Four implants.Zygomatic arch acts as an anchorage for longer Zygomatic implants and has gained in importance in severe atrophied maxilla management. Vomer Implants may be a good alternative procedure to All on Four when anterior implants undergo failure. Complications from other techniques like sinus membrane perforation and loosening of screws can be overcomed by Pterygoid Implants in which maxillary tuberosity distal to maxillary sinus is used for implant placement. The failures of tilted implants are relatively low thus providing an advantageous outcome for edentulous jaws.*

Keywords: ***Tilted Implants, All on Four, Zygomatic implants, Pterygoid Implants.***

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I. Introduction:

Edentulism leads to reduced chewing efficiency, esthetic compromise , poor dental health and restriction in retreatment due to poor bone quality and quantity. Implants cant be placed in some edentulous patients because of inadequate bone for anchorage, nerve proximation and need for sinus lift procedures, nerve transposition and lateralization, distraction osteogenesis, ridge splitting for a successful outcome. With these procedures, the treatment duration and patient morbidity increases[1]. This leads to the invention of angled implants where implants were placed in a tilted pattern that does not interfere with anatomical structures like maxillary sinus, inferior alveolar nerve canal and mental foramen[2].

II. History Of Implants:

1913 - GREENFIELDS implant (Irridio platinum with gold crown)[3]
1940 - BOTHE, BEATON, DAVENPORT (Titanium) founded the difficulty of bone removal around Titanium [4].
1951 - GOTTLIB LEVENTHAL founded Titanium is appropriate for surgery[5]
1965 - BRANEMARK (Titanium) - Osseointegration

1990 - Angled Implants which includes Zygomatic and Pterygoid implants[2].
2003- All on Four concept introduced.

III. NEED FOR TILTED IMPLANTS:

Tilted implants are beneficial in the management of atrophied jaws by eliminating the need of bone augmentation. During full mouth rehabilitation, tilted implants reduces the length of cantilever and increase the antero - posterior spread [6]. Complications associated with implant surgeries like bone resorption and risk factors like poor bone quality and extent of
maxillary sinus, position of mandibular nerve & anterior loop of mental nerve especially in the posterior aspect can be given proper attention[7].

IV.RATIONALE OF TILTED IMPLANTS:

1. Primary implant stability (35 - 45 N cm of insertion torque) can be attained[8].
2. Can be placed in alveolar bone with a minimum width of 5 mm and minimum height of 10mm from canine to canine.
3. Efficiency of chewing and bite force has been improved in relation to masticatory function[8].

V.ADVANTAGES:

1. With minimum of bone volume, greater stability can be attained and implants of longer lengths can be placed which increase the bone - implant contact and reduces the necessity of vertical bone augmentation.
2. Better clinical outcomes.
3. Bone grafting not required.
4. As an alternative for bone grafting in patients/cases where it is not feasible or advisable.
5. Anatomic structures are not included because of angulation.
6. Advantageous in biomechanics.
7. Reduces the cantilever lengths.
8. Bypasses the necessity of Maxillary sinus lift procedures.
9. Better uniform load distribution [9].
10.

VI.DISADVANTAGES:

1. Technique sensitive.
2. Surgeons expertise needed.
3. A computer guided procedure.
4. Requires correct angulation to prevent worse results.

VII.COMPARISON OF TILTED AND NON TILTED IMPLANTS: (Table 1)

TILTED IMPLANTS	NON - TILTED IMPLANTS
By passing of anatomical structures	Care to be taken for anatomical structures
Reduction in cantilever length	No reduction in cantilever length
Better uniform load distribution	Load not evenly distributed
Immediate loading enabled	Immediate loading not enabled.
Greater implant lengths used	Sizes are selected by taking anatomic structures into account.
Anchorage and primary stablility attained with zygomatic and pterygoid bone	No involvement of zygomatic and pterygoid bone
Augmentation grafting & sinus lifting procedures are avoided	These procedures are performed in some cases

VIII.IMPLANT DESIGN:

1. Angulations corresponding to tilted implants - 12°, 24°,36°
2. Diameter - 4,5,6 mm
3. Length - 8.5 mm to 18 mm
4. Connections - External Hex, Trihex and internal Octagon.

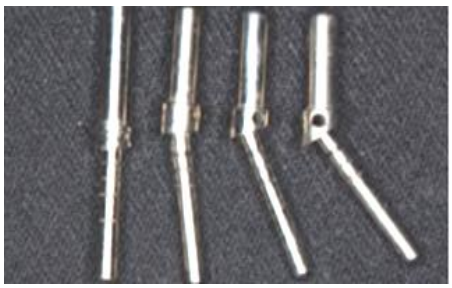

Figure 1 : Implant Design - 0°,12°,24°,36°

IX.TYPES:

1. All on Four
2. Zygomatic implants
3. Pterygoid implants

X.ALL ON FOUR IMPLANTS:

This concepts was introduced by PAULO MALO and his co-workers in 2003 [10 11]. This procedure aimed at the conversion of edentulous patient into an effective restoration involving four implants [12]. With minimum bone volume, greater stability can be achieved and implants of longer lengths can be placed which increases the bone implant contact. In maxilla it provides better anchorage in better quality bone (anterior) and bi cortical anchorage in the cortex of sinus wall and nasal fossa [12].

PRINCIPLE OF ALL ON FOUR:

A full arch provisional, fixed and immediate loaded prosthesis supported by four implants - two straight implants anteriorly and two angled implants posteriorly [12].

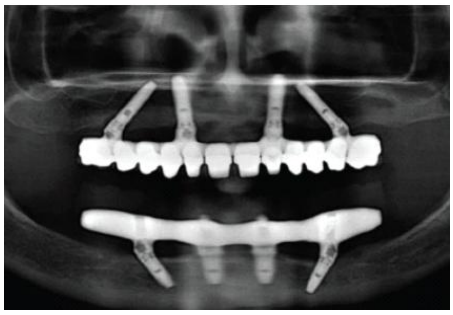

Figure 2 : Principle of All on Four

SURGICAL PROCEDURE:

In maxilla, two distal implants are placed posteriorly which are tilted anterior to maxillary sinus and in the mandible, it is just tilted anterior to mental foramen. It should be inserted at an angle of 30° to 45°. For the implants to be placed in correct position, angulation and emergence , the use of surgical guide is mandatory. The placement of guide is 2mm into a prepared osteotomy site which is in the midline of maxilla or mandible and a titanium band is contoured. Another use of the guide is the tongue retraction in case of mandible. The vertical lines which are present on the guide acts as a reference point for drilling and the angulation should not exceed 45°. Alternatives for surgical guide may include angulated pins, dentures and templates. The A-P spread and the prosthesis stiffness may prevent the implant from bending, when the implant acts as a component of the prosthesis [13]. The stress concentration of the implant can be reduced by the short cantilevers of the posterior distal implants [14]. Implants splinting resulting in decreased stress concentration in comparison with that of axial implants [15]. There may be a fracture of screw or the whole framework when the distal cantilever exhibits an increased length [16].

LOADING PROTOCOL:

Micro damage may occur in the bone around the implant when immediate loading is done after placing the implants. No damage will occur if loading is planned after the healing period.

Success rates depends on:

1. Splinting with provisional prosthesis after surgery.
2. Canine and the premolar are provided with bilateral occlusion.
3. Greater A-P spread.
4. The distal part of the prosthesis should be in under or in non occlusion [17].

VOMER/NASAL CREST IMPLANTS FOR ALL ON FOUR IMMEDIATE FUNCTION:

In case of severe atrophy, when Bucco lingual width in 1-3 mm, there will be difficulty in attaining the immediate function [18] [19]. The introduction of M-4 protocol, involving the M- Point, which is the piriform rim with its maximum bone mass above the nasal fossa for the fixation of the implant [20 - 22].

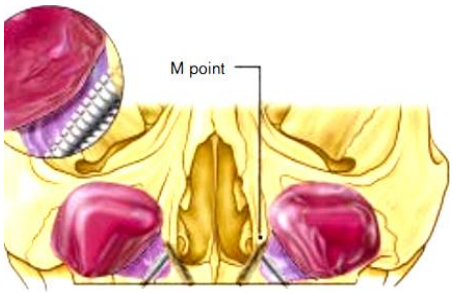

Figure 3 : M point (Piriform rim above the Nasal fossa)

Sometimes vertical reduction may be demanded for accomodation of the prosthesis [23]. Also grafting may be initiated in case of trans sinus procedures [24] [25].

In All on Four procedures, the involvement of zygomatic implants take place when posteriorly the implants cant be placed [26]. Likewise, anteriorly, when there is a scarcity of Piriform rim, the nasal bone can be taken into consideration for implant fixation because the nasal bone is devoid of atrophies and sometimes more pronounced when attached to vomer bone. Vomer implant may be a good alternative procedure in all on four when the anterior implants undergo failure and the vomer location can be used directly without preparing into the involved failed site [27]. The V point (nasal crest/ Vomer) can also be used when there is a narrow alveolar process. This procedure can be done without involving the nasal fossa or the incisive canal. In this procedure, with the lateral incisor location, the implants can be angulated up to 30° towards the mid line. They attain the stability from the mid maxillary basal bone or the nasal crest.

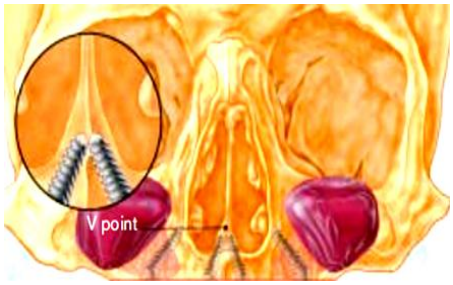

Figure 4 : V Point (Nasal Crest or Vomer bone)

XI.ZYGOMATIC IMPLANTS

In order to avoid grafting procedures, the alternative found are Pterygomaxillary suture, tilted/short implants [28]. But the Zygomatic implant has gained importance in maxillary atrophies and maxillectomy defects [29]. Initially the Branemark pattern of zygoma implant was used for trauma, tumours and congenital anomalies [30]. The zygomatic arch acts as an anchorage for implants of longer lengths. BOTHOR et al introduced multiple zygomatic implants (2 -3) in each side [31].

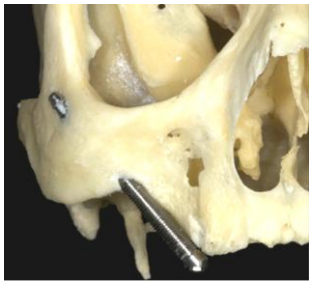

Figure 5 : Zygomatic Implant

USES :
1. As a support in maxillary posteriors together with sinus pneumatization and ridge resorption. It can be planned along with 2-4 anterior axial implants.

CONTRAINDICATIONS:
Absolute:
1. Acute sinus infection.
2. Pathologies involving maxilla or Zygoma.
3. Uncontrolled / Malignant systemic disease.

Relative:
1. Chronic sinusitis
2. Bisphosphonate usage
3. Smoking

PRESURGICAL EVALUATION:

After clinical examination, radioglogical examination provides correct planning for zygomatic implant [32]. CT is essential for determining implant site, path and the sinus anatomy, the Zygomatic arch and the alveolar crest also evaluated. Considerations has been given for angulations, emergence and implant to sinus. The emergence profile falls in the palatal aspect of the second premolar and dependent on the zygomatic bone, sinus and alveolar crest. With the evolution of the new technique, an extra maxillary sinus approach has been derived. BEDROSSIAN et all divided maxilla into three zones: [33]**(Table 2)**

ZONES	AREA
Zone 1	premaxilla
Zone 2	Premolar area
Zone 3	Molar area

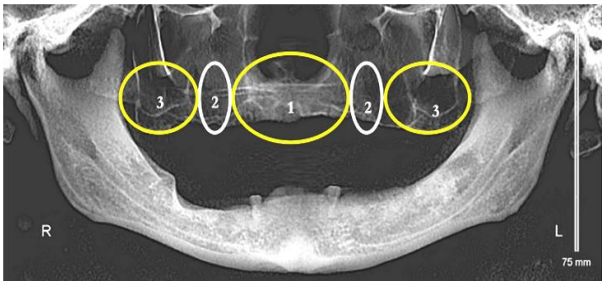

Figure 6 : Maxillary zones classified by Bedrossian

TREATMENT BASED ON MAXILLARY ZONES: (Table 3)

PRESENCE OF BONE	TREATMENT
Zone 1, 2 , 3	Traditional axial implants
Zones 1, 2	Four traditional implants (tilted)
Zone 1	Zygomatic implants + 2-4 traditional implants
Insufficient bone	4 zygomatic implants

ZYGOMA ANATOMY:

NKENKE et al made a study with zygomatic bone and came to a conclusion that zygomatic trabeculae was not appropriate for implants but found positive with the cortical engagements (lingual cortex of the maxillary alveolus, cortical floor of the maxillary sinus at the implants crest, and the cortex of the zygomatic bone at the apexx) [34]. CORYELLO et al studied the zygomatic bone and the drilling length of the holes using extra sinus approach[35]. He found that extra sinus approach produced drilling holes longer than the originial Branemark technique and concluded that this longer drilling holes suitable for increased primary stability.

DESIGN OF ZYGOMATIC IMPLANTS:

According to Branemark technique, the zygomatic implant was inserted in the 2nd premolar region from the palatal aspect through the maxillary sinus into the zygoma. It resembles like conventional implants but has got its length and diameter increased. Available lengths - 30 - 52.5 mm with machined surface [36]. Diameter of the apex - 4 mm and that of the crest - 4.5 mm. For connection with abutments, the head was provided with inner thread and recently the head was angulated to 45° and surface with a moderately rough oxidized threaded surface [37]. Recently

the commercial forms of zygomatic implants include an oxidized rough surface, smooth mid-implant body, crest with a wide hole and head with an angulation of 55°.

SURGICAL TECHNIQUE:

Anesthesia:

Initially the procedure was under GA with nasal intubation . Later infiltrations with LA (Lidocaine with epinephrine), blocking superior alveolar nerves (posterior, middle and anterior) and palatal (posterior and nasopalatal). Nowadays the procedure is being carried out with LA & oral or IV sedation [28]. This procedure is indicated only for skillful surgeons and a procedure of less than 1.5 hours.

Four techniques of LA approach:

1. Infiltration from central incisor to third molar (3.6 ml) and blocking PSA nerve about 1 cm palatal to bone crest.
2. Orally an infra orbital nerve block.
3. Greater palatine nerve block
4. Through the skin, infiltration around zygoma.

Original Protocol:

Initially it was a vestibular Lefort Type - II incision, later modified with a mid-crestal and vertical releasing incisions along the posterior aspect of infra zygomatic crest. The landmarks need to identified are anterior border of zygomatic arch and lateral part of Orbit. A mucoperiosteal flap raised through which posterior aspect of zygomatic complex, lateral wall of maxillary sinus and alveolar crest gets exposed. In order to determine the drilling direction, an indicator is used. Laterally to the sinus, 10 mm wide , a bony window is created. Sinus membrane relieved from sinus walls. Drilling has been made through the alveolus of zygomatic bone. Using depth gauge, the implant lengths are selected. Attention needed not to enlarge the palatal holes.

MODIFICATIONS: ZYGOMATIC ANATOMY GUIDED APPROACH (ZAGA) :

In relation to buccal concavities present on the lateral part of the maxillary sinus, the implant head emergence will be more on the palatal side if an intra sinus track is used. This leads to large sized bridges and that ultimately results in discomfort in hygiene maintenance and speech [37]. In order to overcome the issue, Zygomatic Anatomy Guided Approach (ZAGA) has evolved, which is an extra sinus approach. This aims at inter individuals anatomic differences. The anatomy provides the information for the implant site and there is no necessity of a bony window. Thus the Intrasinus or extra sinus approach is dependent on the relationship between zygomatic buttress of implants starting point. As a result a classification namely ZAGA 0- IV was evolved which is useful for treatment planning [38] [39]. This technique provides bony support, at the maxillary wall in extreme atrophy cases. Wall osteotomies are sealed by the implants leading to no sinus contaminations. No compromising of the crestal bone, and there is integration at the implant body and neck levels with ZAGA 0 - IV utilizing available crestal alveolar bone.

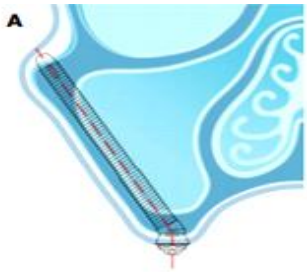

Figure 7 (a): Type - 0 : Flat Anterior Maxillary Wall where the zygomatic implant body present inside the Sinus wall

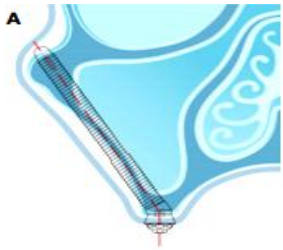

Figure 7 (b) : Type - 1 : Concave Anterior Maxillary Wall where the zygomatic implant perforates the maxillary wall but most of the body present inside the boundaries.

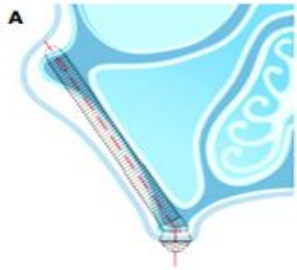

Figure 7 (c) : Type - 2 : Concave Anterior Maxillary Wall where the zygomatic implant body placed outside the sinus wall and no space between implant and maxillary bone

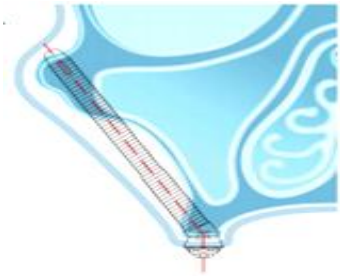

Figure 7 (d) : Type - 3 : Very concave Anterior Maxillary Wall where the middle part of zygomatic implant body doesnot touch the bone

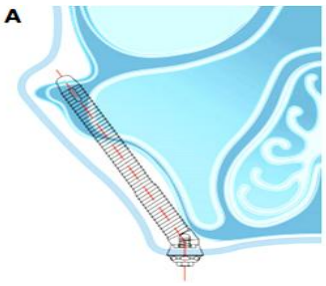

Figure 7 (e) : Type - 4 : Atrophied Maxilla both vertical and horizontal where implants are placed in extramaxillary approach

XII.PTERYGOID IMPLANTS:

These implants were introduced by TULASNE 1992 [40]. Solutions for atrophied posterior maxilla are pterygoid implants. The features of atrophied posterior maxilla are 1) Diminished bone height due to sinus pneumatization / resorption of alveolar bone 2) poor bone density (Type III/IV) (LEKHOLM & ZARB) classification [41 - 43]. Complications from other techniques such as perforation of sinus membrane, graft rejection, displacement of grafts into sinus cavities, loosening of screws in tilted implants could be overcome by pterygoid implants in which maxillary tuberosity distal to sinus is used for placement of implants.

Length of these implants will be 15mm to 20 mm [44]. In the pterygoid regions, it provides stability and retention for implants. Because of the anchorage which is bi cortical, improved axial loading and elimination of posterior cantilever is acquired. Other terms used in relation to pterygoid implants are "Tuberosity Implants", "pterygomaxillary implants". According to Glossary of Oral and Maxillofacial Implants, Pterygoid implants are defined as "Implant placement through the maxillary tuberosity into the pterygoid plate". Definition of Maxillary Tuberosity is "The most distal aspect of the maxillary alveolar process"

Figure 8 : Pterygoid Implants

PTERYGOID ANATOMY:
Cancellous bone (Type III & IV) found in Maxillary tuberosity. Cortical bone found in pyramidal process of palatine bone and pterygoid process of sphenoid. Pterygopalatine Fossa(PPF), an important area in implant placement which needs to be monitored carefully during imaging. In PPF, there is involvement of 3 bones - Maxilla, Palatine, Sphenoid.

CONTENTS OF PTERYGOPALATINE FOSSA [45] [46] :
1. Fat
2. Pterygopalatine ganglion
3. Nerves : Maxillary divisions of trigeminal nerve (vidian nerve)
4. Artery: Distal branches of Maxillary artery.
5. Vein : Emissory Vein

Implant placement done through the pterygoid process into pterygoid fossa [47].

CLASSIFICATION BASED ON ANATOMIC LOCATION BY REISER[48]:
1. Tuberosity - pyramidal process
2. Tuberosity - Pterygoid process
3. Tuberosity - pyramidal process - pterygoid process
4. Pyramidal process - pterygoid process
5. Maxillary tuberosity.

PTERYGOID ANATOMIC AND RADIOGRAPHIC PREDICTION (PARP) :
The diagnostic classification PARP was given by LUIS et al. In PARP, the implants choice for each patient is unique. With the help of CT, the degree of sinus invasion is attained through which the anatomical difficulties as well as the type and length of implants can be determined.

PARP CLASSIFICATION: (Table 4)

CLASS 1	CLASS 2	CLASS 3	CLASS 4
Without sinus invasion	Without or minimal sinus invasion	Moderate sinus invasion	Critical sinus invasion
Bone > 13mm	10- 13 mm remaining bone	5 - 9.99 mm remaining bone	<5mm remaining bone
Retromolar / Pterygoid	Retromolar / Pterygoid	Pterygoid	Pterygoids

PROTOCOL FOR PTERYGOID IMPLANTS:
DIAGNOSIS:
A) Presurgical:
1. Clinical findings / medical history.
2. Pretreatment photographs:

Extra oral : Frontal, Lateral and Oblique
Intra oral : Frontal, Right, Left, Upper and lower occlusal views.

3. Radiographs : RVG, OPG, CBCT.

B) Surgical Level:

Suited for all ages and systemic conditions (Diabetes Type 2 with Hb A1c <7%). For beneficial purposes, surgical guides and stereolith are mandatory. In the surgical guides, the points of entry and drilling

angulations are marked. The perforations into the nearby anatomical areas can be avoided with the help of surgical guides.

SURGICAL PHASE:

With the tilt concept, i.e TTPHIL concept, guide is prepared. The surgical site is the 2nd and 3rd molar regions into the junction which is formed by the projection of sphenoid, palatine and maxillary process with the distal angulation of 25 to 45° depending on the relation of floor of maxilla and tuberosity. The length used for the implants are 18 to 25 mm and the diameter of these implants is 3.75 to 4.2 mm. Stability of the implant should have torque level > 40 N cm, if loaded immediately.

XIII.CONCLUSION:

Success in attempting the implant placement previously in atrophied maxilla and mandible is relatively low compared to the recently evolved technique like All on four concept. In All on Four concept, the implant angulation and placement is unique when compared to the conventional axial implants in a vertical manner. The angulations apart from preventing the involvement of anatomical structures also facilitates the longer implants which in turn increases the bone to implant interface. The posterior cantilever length is reduced and the number of implants and components are also reduced. The failures of implants is relatively low, thus providing an advantageous outcome for edentulous jaws.

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