Basal Osseointegrated Implants: Classification and Review

Aakarshan Dayal Gupta[1], Aviral Verma[2], Tanay Dubey[3], Saloni Thakur[4]

ABSTRACT

Restoration of moderate to severely atrophic jaws with conventional implants requires extensive surgical procedures that is expensive, involves a great deal of post-operative discomfort, and does not assure success of the procedure done and the rehabilitation intended. In such scenarios that require such procedures, basal implants come to the rescue.

Basal implants are specifically designed to allow fixed rehabilitation in severely atrophic jaws and several designs of these implants exist today that have made basal implantology flexible enough to accommodate any situation.

Through this article we propose a classification for basal implants based on their morphology and also explain in detail about the various aspects of these implants.

Keywords: Basal Implant, BOI Implant, BCS Implant, Disk Implant, Basal Implantology

INTRODUCTION

Restoring the edentulous maxilla or mandible with implants has become a normal predictable treatment today. For trouble free and successful implant placement it becomes imperative that sufficient bone be available (at least 13-15mm length and 5-7 mm width)[1,2], incase this criteria is not sufficed then the treatment planning for placing implants becomes robust, i.e.; restoring the lost alveolar dimensions needs to be considered to have a predictable successful outcome of the treatment. Such procedures would involve inlay or onlay alveolar grafts, nerve repositioning, sinus lift and even nasal lift, without which treatment with conventional implants might not be very successful[3].

Such extensive surgical procedures also have their own indications and contraindications. To avoid these procedures the other viable option for replacement in atrophic jaws is to change the implant design. Two very successful implant designs and protocols have been demonstrated in the past few decades for replacement in atrophic jaws which are Mini Dental Implants and Basal Implants.

Basal implants are dental implants that employ the basal cortical portion of the jaws for implant retention. These implants are uniquely and specifically designed for the sole purpose of gaining anchorage from the basal cortical bone and have gone through several changes and modifications in the past several decades. The modern basal implant has a sophisticated yet simple design, surgical protocol and is a prosthetic friendly system. These properties have led several practitioners around the globe to include basal implantology in their practices and so far this system has delivered fairly successful results. This article will review this unique implant in detail and will provide an insight into the philosophy of basal implantology[1, 2, 4, 5].

INCEPTION

Over the years basal implants have been developed and improved in several stages by majorly the German and French dentists. The first single piece implant was developed and used by Dr. Jean-Marc Julliet in 1972 and has been used to this very day successfully, the only disadvantage is the lack of a surgical kit[4, 6]. To overcome this disadvantage in mid 1980s French dentist Dr. Gerard Scortecci improved the basal implant system with matching surgical tools and external and internal connections for the prosthetic superstructure; he called them "Diskimplants"[6].

Since 1990s several interested German dentists developed new implant systems and surgical tools based on Dr. Gerard Scortecci's Diskimplant, this gave rise to the development of the modern Basal Osseointegrated Implant (BOI), also known as Lateral Implant. These implants were designed to enable masticatory load transmission in the vertical as well as its basal part[4, 6].

In 1997 Dr. Stefan Ihde started manufacturing lateral basal implants like the Diskimplants. These implants had limited shapes and sizes and their surface was initially roughened. Soon Dr. Stefan Ihde improved the basal implant; the round base plates got edges, preventing early rotation of the implants in the bone before integration, in 2002 fracture-proof base plate was invented and later patented in Europe and United States, bending zones in the vertical implant shaft were introduced, in 2005 screwable designs (BCS, GBC) were introduced[4].

In 1999 vertical shaft surfaces were polished, from 2003 the whole basal implant was produced with polished surface, as polished surfaces show no tendency to inflammation, and in case of sterile loosening, reintegration of the implant was possible if the load was adjusted in time. Roughened osseous surfaces were found to lack this ability. The design was developed to leave enough elasticity for the development and functional stimulation of bone[4].

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RATIONALE FOR USING BASAL IMPLANTS

According to the concept of basal implantology the jaw bone comprises of two parts the tooth bearing alveolus or crestal part and the basal bone. The crestal bone is less dense in nature and is exposed to infections from tooth borne pathologies, injuries or iatrogenic factors and is therefore subject to higher rate of resorption whereas the basal bone is heavily corticated and is rarely subject to infections and resorption. It is this, i.e.; the basal bone that can offer excellent support to the implants because of its densely corticated nature, at the same time the load bearing capacity of the basal bone is many times higher than that offered by the spongy crestal bone. This rationale stems from Orthopedic surgery and from the experience that cortical areas are essential, since, they are resistant to resorption, as a result basal implants are also called as "Orthopedic Implants"[3, 4, 5, 6].

Basal Implant Types Based on Morphology

There are four basic types of basal implants available-

I Screw Form.
II Disk Form.
III Plate Form.
IV Other Forms.

Both of the types can be further categorized into-

I. Screw Form
   a. Compression Screw Design (KOS Implant)
   b. Bi-Cortical Screw Design (BCS Implant)
   c. Compression Screw + Bi-Cortical Screw Design (KOS Plus Implant)

II. Disk Form
   Basal Osseointegrated Implant (BOI) / Trans-Osseous Implant (TOI) / Lateral Implant-
   1) According to abutment connection-
      i. Single Piece Implant.
      ii. External Threaded Connection.
      iii. Internal Threaded Connection-
         a) External Hexagon.
         b) External Octagon.
   2) According to basal plate design-
      i. Basal disks with angled edges.
      ii. Basal disks with flat edges also called as S-Type Implant.
   3) According to number of disks-
      i. Single Disk.
      ii. Double Disk.
      iii. Triple Disk.

III. Plate Form
   a. BOI-BAC Implant.
   b. BOI-BAC2 Implant.

IV. Other Forms
   a. TPG Implant (Tuberopterygoid).
   b. ZSI Implant (Zygoma Screw).

Implant Morphology

The BOI and BCS implant being produced today has a smooth and polished surface as it was found that polished surfaces are less prone to inflammation (mucositis, peri-implantitis) than rough surfaces[4, 5, 6]. The KOS and KOS Plus implants are surface treated (sand and grit blasting with subsequent acid etching), however, the implant neck is kept highly polished in KOS implant[4]. In the KOS Plus implant, its neck and the basal cortical screw part are kept heavily polished[4].

A. BOI Implant Morphology

The BOI implant is manufactured either from pure Titanium or from Titanium Molybdenum alloy to enhance strength of the implant[1, 4]. These can be either single piece or two piece, following are the parts of the BOI implant (Fig. 1)-

a) Abutment portion

In single piece BOI implants the abutment portion is conical and remains exposed in the oral cavity, whereas in two piece BOI implant the abutment portion can be an externally threaded screw or an internally threaded screw with either an external hexagonal or octagonal restorative platform[4].

b. Neck

It is the portion lying directly below the abutment portion. This portion may or may not be constricted in diameter; constriction provides better post-healing gingival adaptation and also reduces rigidity and allows for bending by 15°-25°[1, 4].

c. Vertical Shaft

This is that portion that connects all the components of the implant. The shaft is kept smooth and polished to discourage plaque accumulation and inflammation; also it can be either elastic or rigid depending on the diameter and the type of titanium used. The vertical shaft is purely a load bearing component and is usually 10 – 13.5 mm long[4].

d. Crestal Disk

It is the first disk in the implant. It is called crestal disk as it lies in the crestal bone after placement of the implant. This disk serves a dual purpose i.e.; immediately after implant placement this disk provides and maintains primary stability and after osseointegration this disk converts into a load bearing and distributing component[4,6].

e. Basal Disk

It is the second disk at the base of the implant and is the last component in the implant body. This part is

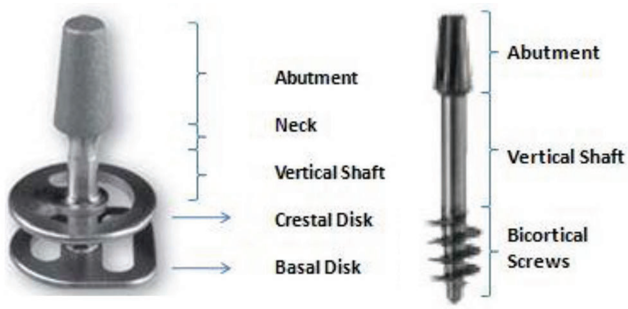

Figure-1: Basal Disk Implant / Basal Osseointegrated Implant (BOI); **Figure-2:** Bi-Cortical Screw (BCS) Implant also kept polished and is a load bearing and distributing component. The part of the shaft connected to the basal disk is elastic and can also be bent by 15°-25°[4, 6].

Distance between the crestal and basal disks is usually 5 mm.

B. BCS Implant Morphology

These are single piece implants designed similarly to the BOI implant with modifications in the abutment and the implant portion. BCS implant abutment can be Conical Straight, Conical Angled and Multi-Unit abutments. Unlike the BOI implant which comprises of disks in the implant portion, the BCS implant has wide diameter cutting screws which helps in engaging the buccal and palatal/lingual cortical plates and initially provide primary stability and load bearing capacity to the implant and later on act as a load bearing and distribution component[4, 5] (Fig. 2).

These implants are also heavily polished and are flapless implants with a very small mucosal penetration diameter[3, 6].

C. KOS and KOS Plus Implant Morphology-

These implants are single piece implants and are manufactured from Titanium Molybdenum or Titanium Aluminum Vanadium alloy. These implants are designed like compression screws, i.e.; these implants when screwed into the bone will compress the cancellous bone surrounding the implant to form more compact and dense bone[1, 4, 8] (Fig. 3).

i. Abutment Portion[1, 4]

This is the restorative platform of these implants and remains exposed in the oral cavity. These implants offer a wide variety of abutment options which are-

a. Conical Straight abutments for cemented crowns, this abutment might also have a vertical microgroove that serves as an anti-rotational feature.
b. Conical Angled abutments.
c. Locator abutments.
d. Ball abutments.
e. Multi-Unit abutments.

*(these abutments are part of single piece implant)

ii. Neck[1, 4]

This part of the implant is highly polished and is constricted to aid in better gingival adaptation and to discourage plaque accumulation. The neck of the implant is bendable by 15°-25°.

iii. Implant Portion[1, 4]

This portion of the implant has the threads which have wide structure and wide turns this enables them to apply compressive forces on the cancellous bone and convert it to a denser cortical like bone. In KOS Plus the apical third of the implant comprises of the basal cortical screws these additional screws which aid the implant in engaging the buccal and palatal/lingual cortical plates and help in gaining primary stability and later function as a load bearing and distributing component. It should be noted that in KOS Plus implant the BCS part is always highly polished.

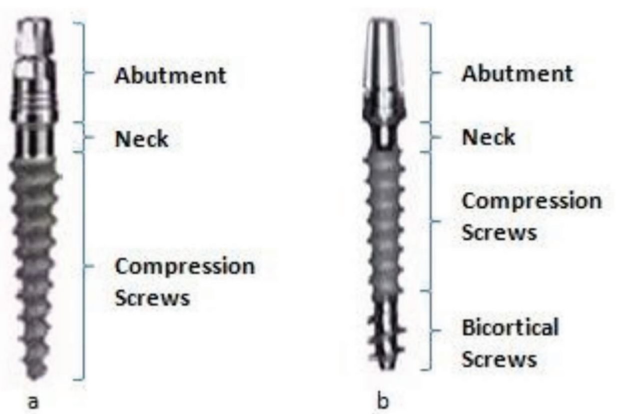

Figure-3: a. KOS Implant with Compression Screws; b. KOS+ Implant with Compression and Bicortical Screws

SURGICAL TECHNIQUE

Unlike conventional implants basal implants have a different surgical approach. The technique is simple and easy to execute and does not involve extensive drilling of bone thus avoiding thermal injury[4, 9]. Throughout the surgery the mode of irrigation used is external and usually for almost any case a single pilot osteotomy with a "Pathfinder Drill" is sufficient for KOS, KOS Plus and BCS implants, the kit also consists of manual drills for a controlled osteotomy preparation[9,10]. Basal implantologists do not advocate raising a flap for these implants as it results in a decreased blood supply and also because of the design of these implants raising a flap is pointless, another factor to be considered is the immediate loading of these implants; a sutured site is not a favorable area to receive an immediate prosthesis[4, 9, 10].

For the BOI implant the approach towards the bone is gained by raising a flap laterally and cutting into the bone with disk drills of required size in a lateral direction to form a "T" shaped osteotomy. The implant consequently is placed laterally and the flap is closed over it[11, 12, 13, 14].

Peri-Implant Healing (BOI and BCS Implant)

Since these implants have a unique design their peri-implant healing is also unique. What conventional implantologists call as "Osseointegration" is called as "Osseoadaptation" by basal implantologists, this stems from the fact that the bone with continuous functional loads remodels and adapts over the surface of the implant, the remodeling of bone under functional loads is considered to be the 4th Dimension[4]. According to philosophy of basal implantology the process of Osseoadaptation is carried out by a "Bone Multicellular Unit" (BMU), it is said to be like a cutting cone with a tail, the cutting cone comprises of osteoclastic cells that eat away the peri-implant bone and the tail comprises of osteoblastic cells that lay down bone, as this unit moves in the bone the osteoclastic activity is subsequently followed by osteoblastic activity (Fig. 4). The formation of this BMU takes place when the BOI and BCS implant are subject to immediate loading which leads to remodeling of bone under functional stresses leading to development of this unit, and thus initiates the healing phase and leads to formation of a dense peri-implant bone[4, 15]. The cascade of processes involved is as follows (4)-

I. Activation Phase-

In this phase the precursor cells/human mesenchymal

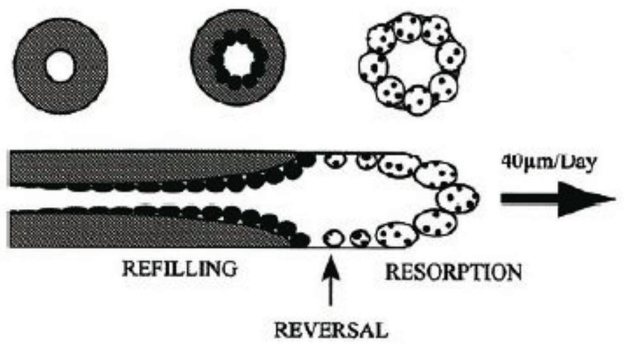

Figure-4: Bone Multicellular Unit (BMU). The Resorption Zone Consists of Osteoclasts, followed by the Refilling Zone Consisting of Osteoblasts, the Zone between the Two is called as Reversal Zone.

stem cells develop into osteoblasts and osteoclasts. This phase lasts for 3 days.

II. Resorption Phase-
During this phase osteoclastic activity occurs which reveals soft and porous bone. Osteoclastic activity occurs at a rate of 40µm/day.

III. Reversal Phase-
In this phase osteoblastic activity takes place. The osteoblasts lay down neo bone in the haversian canals at a rate of 1-2µm/day.

IV. Progressive Phase-
This phase involves the osteoblasts forming concentric lamella in haversian canals, which leads to reduction in diameter of the canal and increase in bone density. At this stage the diameter of the haversian canal is 40-50µm. The bone formed is a Non-Mineralized Matrix Osteoid and this phase lasts for 3 months.

V. Mineralization Phase-
After 10 days of osteoid formation mineralization phase begins. This phase involves two stages-
a) Primary Mineralization Stage-
This stage imparts primary hardness to the osteoid and accounts for 60% of all mineralization.
b) Secondary Mineralization Stage-
This stage imparts final hardness and final morphology of bone. This phase lasts for 6-12 months.

VI. Dormant Phase-
In this phase osteoblasts develop into osteocytes and line the haversian canals and take up mechanical, metabolic and homeostatic functions.

It should be noted that throughout these phases the implants are under functional loads and because of which there is a continuous stimulation of the BMU throughout the life of the implant, which causes the peri-implant bone to become dense (which increases throughout the implants life) and to adapt over the surface of the implant, thus the term "Osseoadaptation", and this is how remodeling plays a key role and is called as the "4th Dimension"[4].

In simple terms it can be stated that the peri-implant healing is a life-long process utilizing the concept of micro-motion and bone compression, that's why these implants are also called as "Orthopedic Implants" as they employ the same principles of peri-implant healing and bone densification[4].

As far as the KOS and KOS plus implants are concerned, since these implants are surface treated, peri-implant healing takes place according to concept of osseointegration and remodeling is a life-long process.

Basal Implants for Atrophied Ridges

Rehabilitating atrophied ridges poses a challenge for the prosthodontist be it fixed or removable. Restoration of such cases involves extensive planning including the option of pre-prosthetic surgery; basal implantology negates any need for extensive surgeries. Unlike conventional implantology where ridge augmentation is indicated to enable placement of implant with appropriate dimensions, basal implants can be used in any size and in combination with any implant. However, there is a certain methodology to how atrophied ridges need to be rehabilitated. Following are the points that are considered prior to rehabilitating atrophied maxilla and mandible-

I. General Systemic Considerations[1, 4]
According to basal implantologists it doesn't matter until the patient has had a recent myocardial infarction, cerebrovascular accident, immunosuppressant therapy, chemo and/or radiotherapy and bisphosphonate therapy. Diabetes is not a huge concern as long as blood sugar levels are in control, also it doesn't matter if the recipient is a smoker or not.

II. Biomechanical Considerations[4]
The grades of bone density given by Dr. Carl E. Misch are not relevant to basal implantology as the drilling sequence and method of placement is completely different. Measuring bone density is also not relevant as the measured parameters will change on insertion and loading of implant.
Bone is a visco-elastic structure and so is this implant, therefore, the phenomena of stress shielding is avoided.

III. To Load or not to Load, that is the Question???[4, 15, 16]
According to philosophy of basal implantology the cranial bone is permanently in a state of torsion, i.e.; there are constant lateral stresses being applied to the cranial bone at all times due to action of the attached facial muscles, therefore, there is no such thing as an "unloaded" implant as lateral forces will always exist no matter the implant receives a superstructure or not. Considering this phenomena, basal implants can either be left without a superstructure till completion of the healing phase or they can receive a superstructure immediately, after 3 days, 1 week, 6-8 weeks, or temporary restoration can be done for 3-6 months followed by definitive restoration.

IV. Which Jaw to Restore First???[4]
The stomatognathic system consists of stationery (maxillary bone) and a mobile (mandibular bone) component, the role of the mobile component is to apply forces and the stationery component absorbs

a considerable amount of the forces applied. Due to the above mentioned purpose of the jaws, it becomes imperative that the mandible should be restored first, also a conventional mandibular denture on an atrophied foundation is unstable, therefore, chewing function becomes poor and gradually the associated muscles lose their tonicity, because of fixed rehabilitation these adversities are avoided, thus, mandible should be restored first.

V. Treatment of Atrophied Ridges

a. Atrophied Mandible-

Over the years two schools of thought have developed regarding implant restorations in atrophied mandible, they are-

i. Multi-Implant Concept of French School[4, 6]

Propagated and founded by Scortecci this school favors a large number of basal implants in the mandible mostly around 7-12 implants. According to this school basal and crestal implants are combined to result in a restoration that is so rigid that it does not permit any torsion across the mandible also this does not allow the jaw system to reorient forces. Since, it is almost impossible to stop mandibular torsion, there is generation of excessive forces on the implant body which leads to overload osteolysis and causes implant failure.

ii. Strategic Implant Positioning Concept of German School[4, 15]

This school was founded by Dr. Ihde. According to this school 4 implants are placed in the mandible preferably in the canine and second molar regions this allows for mandibular torsion and reorientation of forces which gets compensated by flexibility of the prosthesis, thus, overload osteolysis and implant failure is avoided.

Infraneral Implantation Technique[4, 15, 17]

In the atrophied mandible with advancing resorption the IA nerve lies closer to the crest, in such cases it becomes difficult to place crestal implants without bone augmentation or nerve repositioning. BOI implants don't require such procedures prior to their placement as the osteotomy preparation can be modified, i.e.; the osteotomy prepared for the basal disk is prepared approx. 2-3 mm below the nerve, this way the basal disk gets inserted below the nerve and need for extensive procedures is avoided. This technique is also called as Infraneural Implantation (Fig. 5).

b. Atrophied Maxilla[4, 6, 18]

The resorbed maxilla poses a considerable challenge for implant restorations. The pneumatized sinus and the porous bone make implant placement a challenging task. The porous bone is taken care of by the compression screw implants, whereas, for the sinus two techniques have been described, which describe alternate techniques of placement-

i. Sinus Section Technique-

In this two/three walls of the sinus are sectioned to facilitate placement of the basal disk in the sinus. Basal implantologists leave the option of lifting the sinus membrane and grafting on the operator. The sole purpose of this technique is to gain bi-cortical support; also only one implant can be placed this way in each sinus (Fig. 6).

ii. Tuberopterygoid (TPG) Screws-

These implants are placed in the pterygoid bone and aid in providing additional support to the prosthesis. These are used in conjunct with Sinus Section technique and are placed at 20°-45° in the bone and the angulation between BOI implant and TPG screw should not exceed 90° otherwise prosthesis placement becomes difficult (Fig. 7).

iii. Zygomatic Screw Implant (ZSI)-

These are zygomatic implants that are placed in the zygomatic bone and like the BCS implant these also have sharp edged cortical screws that gain bi-cortical support (Fig. 8).

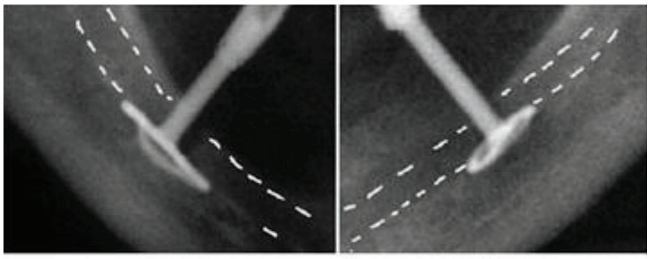

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Figure-5: a and b Showing Infranerval/Infraneural Implantation of Basal Disk Implant (Dotted Line Represents the I. A. Nerve)

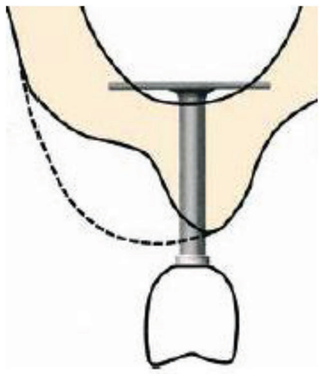

Figure-6: Sinus Section Technique of Implant Placement

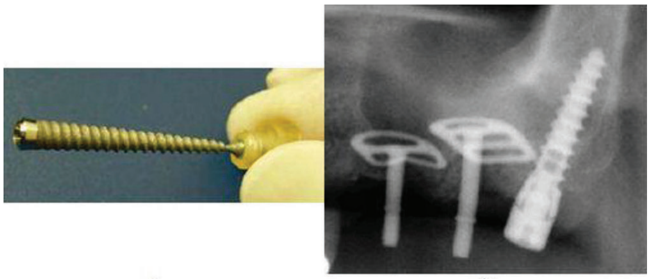

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Figure-7: a. Tubero Pterygoid (TPG) Screw Implant; b. TPG Implant In situ

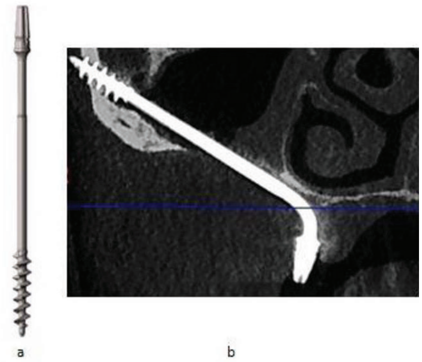

Figure-8: a. Zygoma Screw Implant (ZSI); b. Zygoma Screw Implant In situ

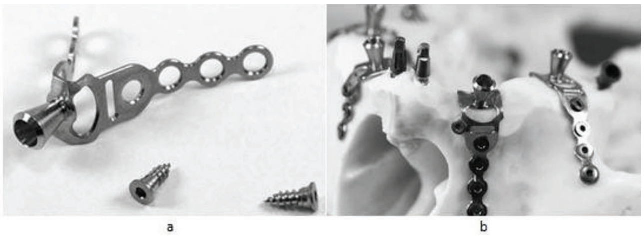

Figure-9: a and b The Cortically Fixed @ Once Concept

c. Cortically Fixed @ Once[19, 20]
This is a very recent protocol introduced by Dr. Henri Diederich in 2013; this protocol is based on basal cortical implantology and is specifically aimed at rehabilitating atrophied jaws irrespective of the amount of bone available without any need for augmentations. This is basically a plate form implant, which looks like mini plates (used for fracture reduction) with an abutment platform, this unique design allows them to be bent and adapt to any surface and is anchored to bone using bone expanding mini screws (Fig. 9). The number of holes required can be reduced; another advantage is their iso-elasticity enabling them to mimic bone. These implants are sub-periosteal implants and so far this protocol has shown good results but more clinical research is required.

Prosthetic Rehabilitation[4, 6, 15, 19, 20]

The aim of prosthetic rehabilitation is to provide esthetics, enable hygiene practice and mainly to avoid overload osteolysis. Esthetics is taken care of by following the three FPs given by Dr. Carl E. Misch. Overload osteolysis is prevented by providing appropriate occlusal schemes which can be bilateral balanced, group function, mutually protected and lingualized occlusion.

CONCLUSION

The research and development these implants have gone through have made them a viable option for restoring atrophied jaws as they don't require extensive augmentation and allow for immediate loading, also, they can be placed with a flapless technique and can be combined with any implant. Despite of the data available on their success in treating a variety of cases these implants have gained little trust among conventional implantologists, it seems further research and development and more concrete data on clinical cases is required to prove their efficacy as a replacement to conventional implants.

However, it cannot be denied that basal implantology fits the principle *"Primum Nihil Nocere"*, i.e., "First Do No Harm". Whenever robust surgical procedures are involved (conventionally), basal implants come to the rescue. Sometimes the best solutions are found in the unconventional. Also, with the proposed classification we have tried to broadly categorize basal implants chiefly based on their morphology/structure, this classification might help the reader in understanding the designs that exist and will give a better understanding of the applications and implications of each implant design.

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