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Review Article

Fixed implant treatment options in edentulous patients: A review of the literature

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ABSTRACT

Conventional complete denture therapy is considered the most basic and initial treatment option for edentulism. However, it is not without its complications, including denture stomatitis, traumatic ulcers, irritation-induced hyperplasia, altered taste perception, burning mouth syndrome, and gagging. Moreover, the treatment outcomes may not meet the individual's psychological or social needs, leading patients to seek alternative treatment options. Dental implants have emerged as a more favourable treatment option, offering various techniques such as all-on-4, all-on-6, zygomatic implants, and patient-specific implants. These techniques provide patients with better treatment outcomes and meet their individualized needs. All-on-four concept that employs tilted implants to restore edentulous patients has also been proposed as an alternative to bone augmentation procedures. The placement of four implants, two implants tilted posteriorly and two vertical implants in the anterior region, allows for avoiding bone augmentation procedures when rehabilitating a completely edentulous jaw with minimal bone volume. The All-on-six concept has evolved recently and provides better anchorage and support. Also, zygomatic implants have also been proven to be an effective treatment modality for the treatment of atrophic and highly resorbed mandibular ridges and in maxillectomy cases.

1. Introduction

For patients who are entirely edentulous, dental implants have become a worthwhile substitute for traditional complete dentures within the past thirty years. The decision between a fixed or removable implant denture depends on various factors.[1] Fixed prosthetic treatment for completely edentulous patients can be achieved using 4 or 6 implants . The All-on-four and All-on-six concepts provide alternative treatment options to bone augmentation procedures.[2,3] For cases of atrophic maxilla, pterygoid implants can also be a useful substitute for tuberosity and traditional dental implants.[4] Patient-specific implants can be fabricated using digital planning procedures, computer-aided design, and selective laser melting techniques to address cases where bone deficiencies prevent conventional dental implant placement.[5] Zygomatic implants have also been shown to be effective in treating atrophic and highly resorbed ridges and maxillectomy cases.[6] This review aims to focus on the various fixed implant-supported treatment options for completely edentulous patients to improve their overall quality of life.

2. Search Strategy

An electronic search was performed in Pubmed, MEDLINE, Google Scholar and Cochrane database from September 2004 to March 2023 using the following keywords: all-on-4 concept, all-on-6, implants, prosthetic, atrophic maxilla & mandible, and edentulous maxillary & mandible alone

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or in combination. Finally, a search was performed of the references of the review articles and the most relevant papers.

3. Discussion

Edentulous patients show a wide range of physical variations and health conditions like difficulty in mastication and speech which lead to poor esthetics and affects the quality of life. [7]

So, the rehabilitation of edentulous patients must be based on a thorough understanding of the chief complaint. The treatment options for such patients include: [8]

1. Complete dentures
2. Implant overdentures
3. Fixed implant dentures

Since the both public awareness and acceptance of dental implants has increased, treatments with implants has become routine dental practice and offer benefits to the patients in terms of convenience when compared to conventional treatments. [9]

The implant-supported treatment can be divided into five prosthetic options:

FP-1: The patient believes that this fixed restoration merely replaces the anatomic crowns of the missing natural teeth. To build this sort of prosthesis, there should be as little loss of soft and hard tissues as possible.

FP-2: It reconstructs the natural tooth's anatomic crown and a piece of its root. When considering the optimal bone position of a natural root, the volume and topography of the accessible bone are more apical.

FP-3: A portion of the soft tissue is replaced by pink-colored restorative materials in this type of prosthesis, which replaces the natural tooth crowns. Similar to FP-2 prostheses, osteoplasty or resorption reduce the bone's initial height at implant implantation. The teeth look more natural in terms of size and shape since the FP-3's gingival color has returned, and the pink restorative material resembles the cervical emerging region and interdental papillae.

RP-4: There is no soft tissue support; it is entirely supported by the implants, the teeth, or both. The attachments often link the RP to a superstructure or low-profile tissue bar that splints the implant abutments.

RP-5: It is a removable prosthesis with soft tissue (primary) and implant (secondary) support.

With the use of dental implants, patients are now able to obtain clinically successful rehabilitation through the use of a fixed prosthesis. Currently, edentulous patients have a full array of treatment options for a fixed implant prosthesis in both the maxilla and mandible. [10]

3.1. Advantages of fixed prosthesis: [11]

1. A fixed prosthesis provides the psychological advantage similar to natural teeth.
2. The retentive nature of a fixed prosthesis allows it to remain in place during mandibular movement.
3. Provides an ideal stability of the prosthesis by maintaining the determined centric occlusion.
4. Higher bite forces have been documented for fixed prostheses on implants.
5. Less Bone Resorption.
6. Reduces the soft tissue coverage and extension of the prosthesis.
7. With a fixed prosthesis, only 8mm of space between the crestal bone and the occlusal plane is required for a zirconia prosthesis and 10 mm for a porcelain fused to metal prosthesis.
8. A fixed implant prosthesis is ideal for patients with limited dexterity, such as those with autoimmune disorders.

3.2. Implant treatment options for fixed restorations based on the number of implants for mandible: [11]

Option 1 for Treatment: The Brånemark Method In order to replace the mandibular posterior teeth, this treatment plan calls for four to six implants placed between the mental foramina and bilateral distal cantilevers, usually to the first molar region. There is no noticeable torsion or flexing of the jaw between the mental foramina. Therefore, anterior implants may be splinted together without risk or compromise and can result in 80% to 90% implant survival rate for 5 to 12 years after the first year of loading.

Option 2 for Treatment: Revised Brånemark Technique because the mandible stretches distal to the foramen, a minor deviation from the ad modum Brånemark technique involves positioning extra implants above the mental foramina. There are various benefits of having an implant above one or both foramina:

1. The number of implants may be increased to as many as seven, increasing the implant surface area.
2. The A-P spread is greatly increased.
3. The length of the cantilever is reduced dramatically.The cantilever's length is drastically minimized.

Treatment Option 3 Anterior Implants and Unilateral Posterior Implant: In this, additional implants in the first molar or second premolar position connected to four or five implants between the mental foramina. The key implant positions for treatment option 3 are the first molar, the bilateral first premolar positions, and the bilateral canine sites. This approach is superior to treatment options 1 or 2 with bilateral cantilevers because the A-P spread is greater, more implants can be used if desired and only one cantilever

is present.

Treatment Option 4 Anterior Implants and Bilateral Posterior Implants: This option is selected when force factors are great or the bone density is poor. In this, implants are placed in all three segments of the mandible. Key implant positions for this treatment option include the two first molars, two first premolars, and two canine sites. Prosthetically, all implants in the anterior and one posterior side may be splinted together for a fixed prosthesis. The other posterior segment is restored independently with an independent three-unit, fixed prosthesis supported by implants in the first premolar and first molar region which eliminates the cantililever.

Treatment Option 5 All-on-Four Protocol: In this, the two most anterior implants are placed axially, whereas the two posterior implants are placed at an angle to increase A-P spread along with decreasing the cantilever length.

3.3. Implant treatment options for fixed restorations based on the number of implants for maxilla: [11]

3.3.1. Maxillary fixed prosthesis treatment option 1

In this, lateral and central incisors are minimally cantilevered facially from the canine position, resulting in a lesser requirement of an implant in the central or lateral position.

3.3.2. Maxillary fixed prosthesis treatment option 2

This option recommends at least three implants in a premaxilla ovoid arch, with one in each canine position and preferably one in a central incisor position to increase the A-P distance.

3.3.3. Maxillary fixed prosthesis treatment option 3

This option suggests 4 implants in a tapered dental arch form to better distribute forces on the anterior implants during mandibular excursions.

3.3.4. Maxillary fixed treatment option 4 (All-on-Four)

This technique places four implants in the maxillary arch with two anterior and two posterior implants angled at 30 to 45 degrees for better spread and stability.

3.4. All-on-four protocol

This concept was developed by Malo and colleagues in 2003 which involved the placement of 2 anterior implants axially and 2 posterior implants distally tilted within the mandibular parasymphyseal region. These implants were immediately loaded with a full fixed acrylic prosthesis within 2 hours of surgery. [12]

Angulation of distal implants provides the following advantages: [12]

1. Increases the anteroposterior (AP) spread
2. Length of the cantilever decreases.
3. Enhances load distribution.
4. Improved load distribution helps minimize any significant movement.
5. Allows the final prosthesis to have 10 to 12 teeth per arch.

3.4.1. Variations in all on 4

3.4.1.1. All-on-4: Zygoma implants and quad zygoma. In this, available bone at a distant site is used when locally insufficient. The apex of the implant is engaged to the body of the zygoma, emerging from the first molar position at a 45-degree angle.

Maxilla according to Bedrossian can be divided into 3 radiographic zones:

Zone 1: Premaxilla

Zone 2: Premolar

Zone 3: Molar

Zygoma implants are recommended when there is inadequate bone in the premolar and molar areas, resulting in only the front premaxilla being available. In such cases, the implant placement involves 2 axial implants in anteriorly and 2 zygoma implants posteriorly. Alternatively, the quad zygoma approach may be used to support a full-arch prosthesis in situations where there is no bone available in the maxilla using 4 zygomatic implants for support. [13]

3.4.1.2. All on 4 V-4. 10-mm-long implants can be placed in 5-mm vertical bone by tilting all four implants in a V configuration toward the midline and allowing a little inferior perforation. Even severely atrophic mandibles can now get quick fixed provisionalization without the need for bone grafting thanks to this procedure. Its benefit is that the larger amount of bone mass in the midline can be utilized, and even when the implant converges toward the midline, the holes that puncture the inferior cortex stay well-spread and relatively distant from one another, lowering the risk of fracture. Patients with significant mandibular atrophy, usually with 5 to 7 mm of native bone remaining, should consider it. [14]

3.4.1.3. All-on-4 shelf: Maxilla. The All-on-4 Shelf technique for the maxilla is a viable treatment option for individuals with mild, moderate, and severe maxillary resorption. This technique involves creating a new alveolar topography by reducing the bone, which enables strategic placement of implants within the premaxilla in an "M" configuration when viewed from the frontal aspect. This provides an interocclusal distance of 22 mm required for the final prosthesis. The convergence angle of anterior and posterior implants is 30 degree. [15]

3.4.1.4. All-on-4 shelf: Mandible. In this, the concept of bone reduction is applied for the rehabilitation of edentulous arch. The ideal requirements for this technique are: flat

alveolus ridge and proper interarch space, a minimum of 20 mm. The implant configuration used in this technique has two notable features. First, the 1:1 ratio represents the available bone height from the alveolar bone to the mental nerve (N point) and the number of millimetres of distance gained by tilting the posterior implant at a 30-degree angle. Second, the posterior implant can be positioned behind the mental foramen when there is sufficient bone present when sufficient bone is present, above the inferior alveolar nerve. This is achieved via a trans-alveolar approach from the buccal to the lingual side, with engagement to the lingual cortex for better anterior-posterior spread.

3.4.1.5. All-on-4 trans-sinus technique . A new technique for the surgical placement of zygomatic implants involves the use of sinus floor grafting bone morphogenic protein, simultaneous trans-sinus implant placement, and immediate function. This approach is indicated for patients with an atrophic maxilla, horizontal bone reduction post-All-on-4 Shelf: Maxilla, or a pneumatized sinus traversing the canine, lateral, and sometimes central incisor regions. The implants are placed in an "M" configuration and engage the "M point," where the pyriform rim has good-quality bone. This technique can provide a stable base for a fixed dental prosthesis and allow for immediate loading of the implants. However, it is important to note that this approach requires a high level of surgical skill and experience and should only be performed by a trained and qualified dental professional. [12]

3.5. All-on-6 approach

All-on-4 is a very successful approach being followed by many clinicians and has gained high popularity among implant dentists as well as patients. But, the drawback is that only a limited number of teeth can be fixed over these four implants and if there is a failure of any one implant, the entire procedure goes back to the initial stage.

So, in order to avoid these complications and fulfill the patient's desire for a 14-unit prosthesis, two additional implants can be placed posterior to the posterior wall of the sinus in the maxillary tuberosity and tilted anteriorly at 45° to reduce the length of the unsupported bridge framework. The severely resorbed posterior maxilla with a large volume of posterior expansion of the sinus often does not leave enough bone volume in the tuberosity region to place an implant of adequate size. In such cases, the implant is inserted in the tuberosity with the apex of the implant at the junction of the pyramidal process of the palatine bone and the pterygoid process of the sphenoid bone. This would then engage all three bone segments in this region. [16]

3.6. Patient specific or subperiosteal implants

Advancements in digital technology, such as 3D printing and direct metal laser sintering (DMLS), have opened up new possibilities for custom-made or patient specific implants and meshes tailored to a patient's specific anatomy. With these technological advancements, clinicians can revisit previous concepts, such as subperiosteal implants, and re-evaluate them based on established anatomical and physiological principles in a new technological context. [17]

They are also a very viable treatment option for defects of Maxillofacial region either acquired or congenital in which Conventional treatment modalities did offer solution to such hard and soft tissue defects but with limited success and required complex clinical and lab procedures. [18]

First of all, a CT scan is obtained and the quality of the data is assessed which consists of checking whether the region of interest is as required.

A 3D model of the jaw is created with the help of the data obtained through the CT scan.

To minimize the number of perforations in mucosa and prevent bacterial invasion, the use of a minimal number of abutments is recommended. Planning dental function and aesthetics in advance is crucial before designing the actual implant. Virtual models are aligned in centric relation using existing intercuspation or x-ray markers in removable dentures as scanning aides. Diagnostic models and wax-ups also aid in planning abutment emergence profiles. The use of virtual teeth during implant modeling can aid in proper abutment placement. When designing fixed cementable abutments, it's important to ensure parallelism of prospective abutments with current partnering abutments and their relation to opposing dentition.

Virtual surgical planning, stereolithographic models (STL), and custom-made titanium meshes are designed before surgery to facilitate both vertical and horizontal reconstruction of the maxillary defect. High-resolution computed tomography with 0.5 mm thin slices is used to plan the surgery, and plaster models aid in determining the optimal position of dental crowns.

The next step is to design and define the shape and extent of the subperiosteal structure, taking into account the position of the prosthetic abutments and the remaining bone in each case.

Surgical Procedure: Once the site is prepared, the implant is placed on the site to verify its adaptation on the residual bone, then fixed with osteosynthetic mini-screws, and the surgical site is sutured followed by prosthetic rehabilitation. [19]

3.7. Materials used for frameworks in fixed full arch implant prostheses

Frameworks provide the foundation for fixed full arch implant prostheses and can be made of either metal or acrylic resin. Different materials are used to fabricate these frameworks, such as cast base metal alloys, titanium, zirconium, and PEEK.

3.7.1. Base metal alloys

They are made of nickel and chromium or cobalt/chromium and iron-based alloys and have good corrosion resistance.

3.7.2. Titanium and titanium alloys

They are corrosion-resistant, biocompatible, and have mechanical properties similar to cast gold alloys, but are difficult to cast.

3.7.3. Zirconium

It comes in three types: fully sintered or Hot Isostatic Pressing (HIP), partially sintered, and non-sintered or "green state," with HIP zirconia being the strongest.[20]

3.7.4. Peek

These frameworks are lightweight, have high elasticity, and provide a cushioning effect on occlusal forces, but they are more expensive than metal-ceramic or metal-acrylic restorations.[21]

3.8. Treatment planning

The clinician should not move forward with fixed restoration until all diagnostic criteria are evaluated which are as follows:

3.8.1. Facial and lip support

Assessment of the patient's facial support with and without the denture in place with the patient facing forward and in profile needs to be made so we can determine which type of prostheses would be more suitable.

3.8.2. Smile line and lip length

Since lip support affects how the maxillary anterior teeth are positioned, it should also be assessed. The maxillary anterior teeth of a patient with a short upper lip will be visible when the patient is in repose, but the anterior teeth in a patient with a long upper lip are typically concealed. A long upper lip is a more favorable situation for the treating restorative dentist.

1. Thickness of the mucosa: The quality of mucosa can be evaluated through palpation, sounding, or radiographs. In edentulous patients, the interdental papillae is often absent due to the absence of interseptal bone and bone remodeling. The appearance of papillae can be simulated by manipulating the soft tissues using an ovate pontic or by using gingival-colored ceramics in cases where implants are improperly positioned.
2. Bone quality and quantity: Computed tomography scans and tomograms reveal the three dimensional architecture of the bone and provide the surgeon with precise representation of the availability and location of bone.
3. Inter arch space: An efficient method of evaluating inter arch space in a patient with an edentulous maxillary arch is to mount the diagnostic casts on the articulator. It helps in deciding whether FP-2 or FP-3 type of prostheses will be suitable for the patient.[22]

3.9. Final prosthesis with various implant modalities

3.9.1. All-on-4 protocol

Final prosthesis fabrication can commence after 4 to 6 months of healing. A bite registration is taken after which, the provisional prosthesis is removed and multiunit laboratory analogs are placed to the denture and mounted against a counter model on an articulator. A putty index is performed on the prosthesis that provides information to the laboratory technician about the length of the future resin pattern framework. Wax try-in is performed with the framework, and the final prosthesis is seated in the patient's mouth.[23]

3.9.2. FP-2 prosthetic options

The most significant factors in selecting prosthetic materials are esthetics, longevity, and durability.

1. Hybrid prostheses: This type of prosthesis uses a smaller metal framework, with denture teeth and acrylic to join these elements together. This prosthesis is less expensive to fabricate and is highly esthetic because of the premade denture teeth and acrylic pink soft tissue replacements. Also, the acrylic reduces the impact force of dynamic occlusal loads and is easier to repair in comparison to porcelain.
2. Porcelain-metal restoration: Precious metals are indicated for implant restorations to decrease the risk of corrosion and improve the accuracy of the casting, because non-precious metals shrink more during the casting process. But, in case of excessive crown height space, a traditional porcelain-metal restoration will have a large amount of metal in the substructure, so the porcelain thickness will not be greater than 2 mm as the large amount of metal in the substructure acts as a heat sink and complicates the application of porcelain during the fabrication of the prosthesis.
3. Monolithic Zirconia: It has high flexural and compressive strength, which approximates 1465 MPa and because of its monolithic nature, minimal interocclusal space is needed for the fabrication of the prosthesis and can be fabricated with 0.5-mm interocclusal space. Antagonistic wear is minimal and is advantageous to porcelain and natural teeth enamel. Lastly, there is less peri-implant disease, as lower thickness of biofilm accumulates in comparison with a porcelain product.[10]

3.9.3. Patient-specific implants

Under LA, the subperiosteal implants are uncovered and multi-unit abutments are placed in order to create a suitable emergence profile. After the tissues around the implants are healed, a splinted open tray impression is taken. After that, a milled substructure is produced and checked in the oral cavity for final fit. After that, the ceramic covering is applied and the final prosthesis is delivered.[5]

3.10. Malo's prosthesis

In excessive crown height space, the major risk factor is mechanical complications of implant-supported rehabilitations like screw loosening or porcelain fractures. So, in these situations, the Malo bridge with customized abutment is the best treatment of choice. The major advantage of this type of prosthesis is that it is possible to remove and repair the fractured porcelain of the individual crown without removing the whole structure.[24]

4. Conclusion

Complete dentures are the minimum standard for restoring edentulous patients. Though they are not always satisfactory due to various complications and psychological factors. Dental implants have become a more acceptable treatment option as they offer a range of choices, including removable and fixed implants, tailored to individual patients, resulting in higher patient satisfaction when the proper protocols and techniques are applied.

5. Conflicts of Interest

None.

6. Source of Funding

None

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