

Prosthodontic Perspective to All-On-4® Concept for Dental Implants

M.TARUNA¹, B.CHITTARANJAN², N.SUDHEER³, SUCHITA TELLA⁴, MD.ABUSAAD⁵

ABSTRACT

The clinical success and longevity of endosteal dental implants as load bearing abutments are controlled largely by the mechanical setting in which they function. The treatment plan is responsible for the design, number and position of the implants. In biomechanically compromised environment such as poor quality bone, strain to the crestal bone can be reduced by increasing the anteroposterior spread of implants, placement of longer implants and maximizing the number of implants. The All-on-4® concept is one such treatment procedure which enlightens us for its use in the completely edentulous patients and which also leaves behind the routine treatment alternative of conventional dentures with successful outcome in the short term, long term and the retrospective studies that have been done in the past. The area of concern for any treatment alternative lies in the success of the prosthesis and its prosthodontic perspective involving the principles of occlusion. This article reviews the All-on-4® concept and its prosthodontic aspects.

Keywords: All-on-4®, Cantilever prosthesis, Implant occlusal scheme, Multi units

Introduction

In some cases of the completely edentulous patients, implant supported prosthesis treatment is almost impossible without complex techniques such as nerve transposition and grafting in the posterior maxilla and mandible. A solution for such situations is the All-on-4® concept. This method advocates tilting distal implants in edentulous arches which enables us in the placement of longer implants, improved prosthetic support with shorter cantilever arm, improved inter implant distance and improved anchorage in the bone [Table/Fig-1]. The "All-on-4®" treatment concept was developed by Paulo Malo with straight and angled multi-unit abutments, to provide edentulous patients with an immediately loaded full arch restoration with only four implants.

–Two placed vertically in the anterior region and two placed upto an angle of 45° in the posterior region.

When used in the mandible, tilting of posterior implants makes it possible to achieve good bone anchorage without interfering with mental foramina in severely resorbed maxillae, tilted implants are an alternative to sinus floor augmentation [1].

General considerations

- To achieve primary implant stability (35 to 45 Ncm insertion torque).
- Indicated with a minimum bone width of 5mm and minimum bone height of 10mm from canine to canine in maxilla and 8mm in mandible.
- If angulation is 30° or more, the tilted implants can be splinted.
- For tilted posterior implants, the distal screw access holes should be located at the occlusal face of the first molar, the second premolar, or the first premolar [2].

Surgical Procedure [Table/Fig-2]

Implants in the maxilla are placed with two distal implants in the posterior region which are tilted anterior to the maxillary antrum while in the mandible implants are positioned anterior to the mental foramen. They should be inserted at an angulation of 30°-45°. The use of the All-on-4® surgical guide assists in ensuring the placement of the implants with correct positioning, angulation and emergence. The guide is placed into a 2mm osteotomy that is made in the midline position of the maxilla or mandible and the titanium band is contoured to follow the arc of the opposing arch. The guide also

assists in retracting the tongue in mandibular cases. The vertical lines on the guide are used as a reference for drilling at the correct angulation, which should not be greater than 45°. The other guides that can be used for implant placement are Template, Angulated pins and Denture [Table/Fig-3a,b].

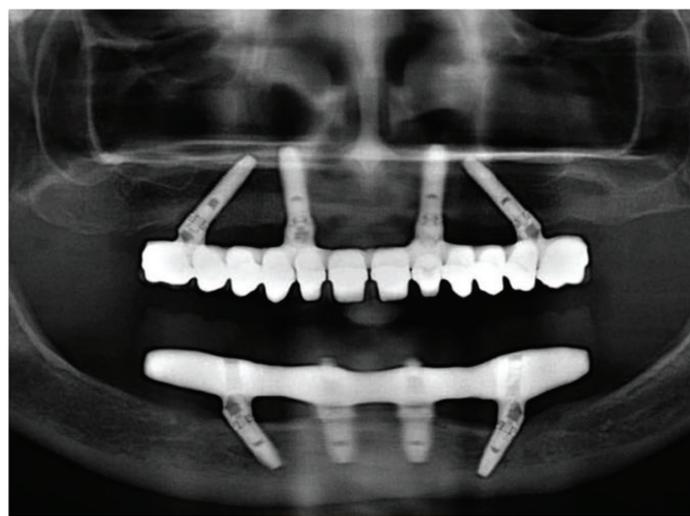
Straight, 17° multiunit abutments and 30° angulated abutments with different collar heights are placed onto the implants. These are used to achieve the correct access allowing relative parallelism and so that the rigid prosthesis can be seated passively.

Success rate in edentulous maxillae

A retrospective clinical study including 242 patients with 968 immediately loaded implants supporting fixed complete arch maxillary all-acrylic prosthesis demonstrated a high survival rate 93% at patient level and 98% at implant level after 5 y of follow up. Recent studies encouraged the use of All-on-4® concept emphasizing that when planning a fixed rehabilitation in an edentulous maxillae using four implants, the quality of bone, the length of implants, the patient's habits and the length of expected cantilever should be considered [3].

Comparison of tilted v/s non tilted implants

If an implant is part of a multi implant supported prosthesis, the spread of implants and stiffness of the prosthesis will reduce bending of



[Table/Fig-1]: All-on-4® Concept

Step 1	Selection Of Case Satisfying The Inclusion Criteria
Step 2	Planning Implant Placement Using All-On-4® Guide(Preferred)
Step 3	Location Of Maxillary Antrum And Mental Foramen With All-On-4® Guide
Step 4	Implant Placement Done Following The Protocols

[Table/Fig-2]: Surgical technique



[Table/Fig-3a,b]: Guides for implant placement., a-guide., b-Template

Rangert	10 mm for a cantilever of 20 mm (2xA-P-spread)for mandibular ISFPs
English	ISFPs should be 1.5 times A-P-spread for mandible maxillary ISFP posterior cantilever should be reduced to 6-8mm due low bone density

[Table/Fig-4]: A-P spread

Step 1	Open tray impression made with wire and GC resin splinting for improved accuracy
Step 2	Final impressions after integration is verified, being splinted with GC resin and metal.
Step 3	All ceramic Zirconia bridge being designed with CAD/CAM technology
Step 4	Use of CAD/CAM zirconia bridge or Titanium framework milled for crown cementation
Step 5	Crowns luted to zirconia framework
Step 6	Implant-supported zirconia bridge framework with individual crowns luted

[Table/Fig-5]: Prosthetic phase

the implant [4]. The more distal position of the posterior implant and the resulting shorter cantilever may have a role in reduction of stress values in the implant [5]. Strain gauge measurements performed by Krekmanov showed no significant differences in forces and bending moments between tilted and non tilted implants [6]. Theoretical models show that an increased prosthetic base, due to the inclination of implants can reduce the force acting over the implants. Therefore, from biological point of view, the position of the neck of the implant can be more important than the inclination of the implants themselves. Bevilacqua et al., demonstrated that tilting of the distal implant by 30° in a FFP decreased the level of stress by 52% and 47.6% in compact bone and cancellous bone respectively, when compared to vertical implants supporting FFP with longer cantilevers [7].

Loading of the cantilever on prosthesis can cause a hinging effect that induces considerable stresses on the implants closest to the load application [8]. When the distal cantilevers of FFP are excessive in length, deformation of the framework can result in fracture of the prosthetic screw, the acrylic resin teeth or even the framework itself [9].

The splinted tilted implants showed lower stresses than the axial implant with cantilever and the reduction of the stresses generated with the prosthesis might help reduce maintenance problems of FFPs v/s those that employ a conventional implant configuration [10]. When a vertical load was applied to the first premolar of the tilted implant, the two neighboring implants mostly shared the load, as the prosthesis was loaded between the mesial and distal implants load was distributed to both supporting implants through the prosthesis, the tilted implant configuration did not show over loading or bending [11].



[Table/Fig-6a, b]: Prosthetic phase a resin splinting., b-final prosthesis



[Table/Fig-7a, b]: Simultaneous bilateral point contacts on canine and posterior teeth and grazing contacts on incisors

Stress patterns on implants in prosthesis supported by four or six implants

A long term study found no significant differences in implant survival in a comparison of complete maxillary prosthesis supported by four or six implants. The stress location and distribution patterns were very similar in both four and six implant models. The cantilever should be minimized as its presence greatly increases stress on the distal implant, regardless of whether or not the prosthesis is supported by four or six implants [12].

Stress patterns around distal angled implants in the All-on-4® concept configuration

A study analysed the photo elastic strain patterns surrounding distal implants placed at 0°, 15°, 30° and 45°. There was no remarkable difference in strain magnitude between models of implants placed at 0, 15, 30. But increase in strain pattern for 45° angled implants [13].

Angled Abutments

In general, the magnitude of stress and strain for angled abutments was within or slightly above the physiologic limits. The use of angled abutments on two tilted implants placed in a curved arch and with cross-arch splinting might help decrease the stresses around the distal implants [13].

Loading on the healing bone

Overloading and fracturing happen more readily in healing bone than in normal bone [14]. Occlusal loading in the period immediately after placement may be sufficient to cause micro damage in the bone surrounding the implant, even though the same load will not do so after healing and adaptation of the bone to the implant. The All-on-4® concept advocates immediate loading. A slight load on healing bone shortens healing time rather than prolonging [15]. Immediately loaded implants osseointegrate provided that forces and implant micromotion are controlled.

Immediate extraction socket placement

The connection of implants may provide a safer transfer of load on each implant and so the placement in healed or fresh extraction bone sights may not influence implant survival when rehabilitating totally edentulous mandibles [16].

From a surgical perspective, the most notable are careful implant site preparation (including tapping), use of relatively low – torque producing implants, the preparation of an osseous shelf to level the alveolar ridge and establish optimum implant sites and the provision of adequate interocclusal space.

From a prosthetic perspective, the high success rate obtained with this protocol, including minimal bone loss even with multiple

extractions and bone reduction followed by immediate function is believed to be as a result of –

- Stable splinting of all four implants with the provisional immediately after surgery,
- Careful occlusal adjustment to provide bilateral occlusion in the canine and first premolar areas,
- Avoid occlusal contact toward the distal of the prosthesis and maximizing the anteroposterior spread [17].

An Anteroposterior spread that minimizes the distal cantilevers and establishes well distributed four-point stability was probably contributory to both implant and prosthetic success. The immediate implant loading and function in the dental extraction setting can be performed with a high degree of confidence.

A-P-spread and cantilever values [Table/Fig-4]

Rangert provides simple guidelines for controlling occlusal loads on implants and prosthetic reconstruction- an A-P-spread(distribution distance between the most anterior and most posterior implants) of 10 mm was proposed for a cantilever of 20 mm (2xA-P-spread) for mandibular ISFPs English proposed Anecdotally that a very reasonable rule of thumb for determining posterior cantilever in mandibular ISFPs should be 1.5 times A-P-spread. According to English, this would allow a 10-12 mm posterior cantilever for the mandible, whereas maxillary ISFP posterior cantilever should be reduced to 6-8mm due low bone density [18].

Open tray multi-unit impression copings are placed onto the multi-unit abutments, which are then splinted with a low shrinkage autopolymerising resin (GC pattern resin) and wire bars [Table/Fig-5,6a]. This ensures an accurate transfer without accidental displacement of the impression copings. An open tray impression is made with a rigid polyvinyl siloxane material (3M ESPE Imprint Putty) to capture the positions of the implants and the soft tissues.

Provisional all-acrylic resin prosthesis is then constructed and issued to the patient within a few hours or overnight. The provisional prosthesis is torqued to 15Ncm. The patient is reviewed after one week, at three weeks, three months and then annually.

At the three month appointment, fabrication of the definitive bridge may be started. The final restorative solution can be a:

1. CAD/CAM designed fixed prosthesis with Zirconia or Titanium framework. Individual crowns are cemented to the final bridge framework.
2. Fixed prosthesis with CAD/CAM designed Titanium or Zirconia framework with acrylic veneering [Table/Fig-6b].
3. Fixed prosthesis with cast metal and veneering porcelain.
4. Removable final prosthesis: e.g. milled bar overdenture, MK1 attachment overdenture.

Comparison of superstructure framework

The first patient with fixed complete dentures were provided with Cr-Co alloy frameworks with resin teeth. This protocol was modified over time and gold alloy casting was introduced to provide a more stable occlusion in metal and to allow porcelain veneering of the framework, however in case like severe bone resorption, large amt of gold alloy had to be cast. To avoid problems with casting few non casting approaches such as premachined gold-alloy cylinders /bars and laser – welded titanium frameworks were introduced. More recently a new protocol based on using computer numeric-controlled milling of a solid block of titanium was developed and is free of the technical challenges involved in previous approaches [19].

Occlusal aspect

Many implant failures can be attributed to improper occlusal design which can concentrate stresses in the bone and lead to rapid bone

resorption. The goal of any prosthetic procedure must include the establishment of a functional occlusion [20].

Occlusal Schemes

Occlusal scheme of implant-prosthetic superstructure basic requirements are

1. Establishment of stable jaw relationships with maximum intercuspal contacts that are bilaterally identical
2. Establishment of “freedom in centric” within the overall occlusal scheme
3. Elimination of any interference between the maximum intercuspal and retruded contact positions
4. Provision of harmonic, free mandibular movements with light tooth contacts during both lateral and protrusive maneuvers.

Occlusal scheme for immediate loading for All-on-Four concept

Avoid or minimize length of cantilever .Simultaneous bilateral point contacts on all teeth, excluding teeth distal to implant emergence. In lateral movements, group function or guidance with flat linear pathways and minimal vertical super imposition excluding teeth in cantilever. In protrusive movements, guidance distributed on all anterior teeth including canines, with flat linear pathways and minimal vertical super imposition. Even if the implant supported prosthesis is opposed to a removable full denture, in excursive movements avoid balancing contacts.

Occlusal scheme for All-on-Four definitive prosthesis [Table/Fig-7]

Simultaneous bilateral point contacts on canine and posterior teeth and grazing contacts on incisors. In lateral movements , canine guidance opposing natural dentition, group function opposing posterior implant supported bridge with flat linear pathways and minimum vertical super imposition [Table/Fig-7a,b]. If the implant supported prosthesis is opposed to removal, complete denture or implant supported over denture or a distal extension cast partial denture leave the most distal tooth slightly out of occlusion and in excursive movements seek one or more balancing contacts, planning greater anteroposterior space at the anterior teeth. The occlusal pattern should have relatively flat cusps i.e. the inclination of the cuspal planes should be less than the inclinations of the condylar path.

- Complete denture opposing All-on-4® concept
- Over denture opposing All-on-4® concept
- Precision attachment opposing All-on-4® concept
- Cast partial denture opposing All-on-4® concept
- Distal tooth out of occlusion
- Balancing contacts
- planning greater anteroposterior space at the anterior teeth

Since the teeth of the distal cantilever are less heavily loaded, the guiding surfaces of the incisors and canines can be expected to undergo increasing abrasions with time, therefore eliminate premature or non working side contacts on the distal cantilever [21].

DISCUSSION

Advantages of the All-on-4® concept

- Angled posterior implants avoid anatomical structures
- Angled posterior implants allow longer implants anchored in better quality bone
- Reduces posterior cantilever
- Eliminates bone grafts in the edentulous maxilla and mandible in majority of cases

- High success rates
- Implants well-spaced, good biomechanics, easier to clean
- Immediate function and aesthetics
- Final restoration can be fixed or removable
- Reduced cost due to less number of implants and avoidance of grafting in the majority of cases.

LIMITATIONS

- Good general health and acceptable oral hygiene;
- Sufficient bone for 4 implants of at least 10mm in length; and
- Implants attain sufficient stability for immediate function.

DISADVANTAGES

- Free hand arbitrary surgical placement of implant is not always possible as implant placement is completely prosthetically driven.
- Length of cantilever in the prosthesis cannot be extended beyond the limit.
- It is very technique sensitive and requires elaborate pre-surgical preparation such as CAD/CAM, surgical splint.

Length of cantilever in the prosthesis cannot be extended beyond the limit.

CONCLUSION

Various researches done on the concept and practice of the rehabilitation has advanced the All-on-4® treatment option from the skeptical to the predictable with commendable success rates. The long term results of this technique and the numerous advantages of immediate loading, the reduced morbidity, the high patient satisfaction and relatively low costs should be taken into account when a decision among the alternative treatment options for an edentulous jaw has to be made.

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PARTICULARS OF CONTRIBUTORS:

1. Professor, Department of Prosthodontics, Kamineni Institute of Dental Sciences, Sreepuram, Narketpally, India.
2. HOD and Professor, Department of Prosthodontics, Kamineni Institute of Dental Sciences, Sreepuram, Narketpally, India.
3. Professor, Department of Prosthodontics, Kamineni Institute of Dental Sciences, Sreepuram, Narketpally, India.
4. Reader, Department of Prosthodontics, Kamineni Institute of Dental Sciences, Sreepuram, Narketpally, India.
5. Postgraduate Student, Department of Prosthodontics, Kamineni Institute of Dental Sciences, Sreepuram, Narketpally, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. M.Taruna,
Kamineni Institute of Dental Sciences, Sreepuram, Narketpally-508254, India.
Phone : 9849033670, E-mail : taruna_e@yahoo.com

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