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REVIEW ARTICLE

Deciphering All-on-4® and Its Perspectives

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ABSTRACT

All-on-4® treatment concept has been widely accepted by implantologist and has become a common procedure in many dental practices. But is it a favorable technique and how long will the implants last when the entire frame work of 12 teeth is embedded in maxillary soft bone and immediately loaded? It is difficult and baseless to argue and conclude the benefits of All-on-4® as the literature lacks required data; nonetheless, this article has tried to provide readers an unbiased opinion, as the final choice of the treatment lies in the clinician's discretion keeping patient needs in consideration.

Keywords: All-on-4®, Immediate loading, Implant, Micromotion, Rehabilitation.

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INTRODUCTION

Oral rehabilitation of edentulism to restore function with implants remains the prime requisite since decades and in order to do so, many techniques have been introduced. From conventional placement of five to eight implants in the maxilla, science has now shifted to All-on-4 concept of immediate loading. The All-on-4® implant concept was developed to overcome anatomical limitations in the alveolar processes, especially in mandible, making it possible to treat without the use of more complex techniques[1] and in the maxilla to avoid sinus lift procedures, providing more stable dentures on straight and tilted implants. But, can maxilla with soft bone of D4 type afford immediate loading and for how long can implants remain stable without being at the risk of failure?

Placement of the implants is multifactorial; since it becomes an expensive treatment with bone augmentation procedures, the patient's choice for the treatment among various options should be considered. Any patient at any given point of time would want minimally invasive, less expensive and a long-lasting treatment. Considering the first two choices, All-on-4® treatment seems to be the best option, but when it comes to "long lasting," All-on-four cannot be implied. However, one of the criteria of implant success is its functional service for 5 years in 75% of cases.[2] Thus, arguing upon its success is rather controversial. This article, however, gives a comprehensive overview of pros and cons of All-on-4® implant placement, nonetheless the final choice of the treatment lies in the clinician's discretion keeping the patient's needs into consideration.

MATERIALS AND METHODS

This narrative review gathered literature from peer-reviewed articles published in indexed journals available in PubMed and other web-based resources.

Micromotion in Immediate Loading

Since long, the concept of osseointegration had been argued upon with the idea of formation of fibrous layer, without which bone to implant contact would not have been possible.[3] Many authors also believed that until and unless the implanted object is not ceramic, osseointegration cannot be achieved.[4] But these theoretical ideas became obsolete when Prof. Per-Ingvar Brånemark and his colleagues in 1950s and 1960s through means of vital microscopy[5] showed the attachment of bone with titanium metal, without the fibrous layer in between, which could not be removed without fracture.[3,6] And soon, it was realized that fibrous layer does not aid in osseointegration, but implant failures.[4] Albrektsson et al[4] stated that "Osseointegration only occurs in perfectly stable situations." They also stated that surgical trauma causes formation of a necrotic zone around the immediately placed implant, irrespective of the precautions taken,[4] which stands abreast with the recent literature[4,7] as both the cells, neutrophils and macrophages associated with clot and necrotic tissue formation, become predominant at 24 to 48 hours.[3] It is only at the fourth day of implant placement that the necrotic bone around implant created at the time of surgery gets resorbed, and

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a well-defined interface zone is formed[8] and by fifth day, there is new bone formation.[9] The initial time period of 4 to 5 days is very crucial for implant success; however, to safely achieve and predict the process of osseointegration, a defined healing period of 3 to 4 months is necessary.[4] According to Schatzker et al,[10] minor movement of implant during healing phase inhibits osteogenesis, thus loading should be delayed until screw threads are filled with callus.[11] Perhaps immediate loading is the most important reason for the formation of connective tissue sheath seen around implants.[12-14]

In much recent data, as compared with the scientific studies of the 1970s and 1980s, Perren[15] explained the same concept through strain theory, which states that "when the ends of a fractured bone are tightly compressed, then almost no movement should be allowed between the fragments, otherwise a stretch or a strain is produced which could destroy the new cells and vessels forming in the gap. In such cases, there is increased osteoclastic activity which enters through the resorption of bone increases over the critical threshold of strain of the regenerated tissue." The same mechanism can be hypothesized at the bone–implant interface of immediately loaded implants.[16] In various experimental studies, it has been stated that a threshold of micromotion between 50 and 100 µm, above which bone resorption takes place, producing fibrosis around endosseous implants.[16,17] Trisi et al[16] hypothesized that increase in the peak insertion torque, micromotion under lateral forces could be reduced. The authors also stated that softer the bone, higher the micromotion will be, contraindicating immediate loading of implants in such situation[16] as can be considered in the case of maxillary soft bone.

The All-on-4 Treatment Concept

All-on-4® immediate loading concept was developed in 2003 and the fact that the patient can walk out of the clinic the same day of implant surgery with affordable treatment cost has made this technique one of the most common in implantology within a short span of time. Based on the success of mandibular All-on-4 technique, Malo et al[18] replicated the same design for the maxilla in 2005, with a huge advantage of not going for sinus procedures in severely resorbed maxillas. Conventional treatment plan involved placement of implants in fairly vertical positions throughout the arch.[19] This approach sometimes may be associated with limitations in the form of sinus in the maxilla and the inferior alveolar nerve and related structures in the mandible, creating problems in the implant placement which often requires for major bone augmentation procedures which again has its own limitations and complications. In order to overcome the aforementioned anatomical limitations, posterior cantilevers were given. However, extensive posterior cantilevers increase occlusal forces and are thus biomechanically unfavorable.[18,20] Thus, the concept of All-on-4® has bridged these limitations and provided clinicians with a solution.

The placement of two straight implants in the region of incisors and two tilted implants in the region of premolar or first molar provides many advantages, the main one being eliminating the use of sinus surgeries and long-term edentulism. Another factor is the cost of the treatment. In a cohort study on cost comparison by Babbush et al,[21] the authors concluded that the All-on-4® is the least costly as compared with the conventional implant treatment. From a prosthetic point of view, tilting the posterior implants and increasing the anterior–posterior spread improves implant success.[22] According to Krekmanov et al,[22] tilting of posterior distal implants reduces cantilever lengths, broadens the prosthetic base, and improves implant-to-bone surface areas as longer implants are used. In their study, tilted implants increased prosthesis length by an average of 6.6 mm in the mandible and 9.3 mm in the maxilla.[22] Other advantages have been summarized in Table 1.[23]

Disadvantages

In a recent systematic review by Heydecke et al,[24] the authors concluded that there is lack of data on survival and complication rates for full arch implant-supported fixed dentures supported by four to six implants. They also concluded that whether there is an indication for implant requirement, i.e., more than six implants, is unclear from the current available evidence. Malo et al[25] in a 5-year retrospective study stated that biological complications occurred affecting 13% (129 implants) in 30% of the patients and mechanical complications occurred affecting 170 implants (17%) in 71 patients (38%).

The main disadvantage of the All-on-4® is that it is technique-sensitive. It takes precision in placing implants between 30 and 45°. In many cases, straight implants and tilted implants touch each other apically, hindering the primary stability. Also the entire maxillary four implants are embedded in soft bone bearing the occlusal load,

Table 1: Advantages of All-on-4®

Advantages
Implants are placed in dense bony structure.
Tilting of implants allows placement of longer implants posteriorly.
Tilting improves anterior–posterior spread of implants.
Better anterior–posterior spread enhances load distribution for prosthesis.
Rigid prosthesis helps in maintaining marginal bone height.
Tilted implants have similar success rate to traditional implants when splinted together.

Table 2: Disadvantages of All-on-4®

Disadvantages
Implant placement is prosthetically driven.[27]
Technique-sensitive: not always possible to place at an angle of 30–45°.
Requires use of elaborate software, such as computer-aided design/computer-aided manufacturing.[27]
Limited length of cantilever in the prosthesis.[27]
Sufficient bone height for four implants of at least 10 mm in length.[27]
Hygiene maintenance becomes a problem.
If one implant fails, sustainability of All-on-4® becomes difficult.

resulting in framework fracture and implant failure.[26] Other disadvantages are listed in Table 2.

DISCUSSION

In 1999, four to six implants were placed in premaxilla to avoid sinus augmentation in 15 patients with severely resorbed alveolar ridge. This can be considered as one of the early designs of the "All-on-4®" concept.[28] But the present design of "All-on-4®" immediate-function used was developed by Malo et al.[1] Earlier many dental practitioners were skeptical in using this technique; however, over a period of time, its use became popular, as many authors showed its successful results stated to be equal or superior to conventional concepts.[29-31] However, doubts and long-standing professional arguments still persist among implantologists as to the use of All-on-4® or not. As authors have aforementioned, patients would always want affordable, quick, and long-lasting treatment so the choice between conventional implant treatment and All-on-4® would largely depend upon patient's discretion.

From a prosthetic point of view, the use of tilted implants may facilitate achievement of the desired implant position by creating a favorable inter-implant distance.[32] Moreover, there is biomechanical advantage in using splinted tilted distal implants over axial implants in supporting distal cantilever units when comparing the coronal stress which has been proved via using finite element analysis.[33] Also, in such multi-implant-supported prosthesis, due to the spread of implants and stiffness of the prosthesis, there is reduced bending of the implant.[34] However, strain gauge measurements between tilted and non-tilted implants performed by Krekmanov et al[22] showed no significant differences in forces and bending moments. But theoretical models have shown that an increased prosthetic base due to implants inclinations force acting over the implants can be reduced. Bevilacqua et al[35] demonstrated that tilting of the distal implant by 30 degrees decreased the level of stress by 52% in compact and 47.6% in cancellous bone, when compared with conventional implants supporting fixed full prosthesis (FFP) with longer cantilevers. Loading of prosthetic cantilevers may cause a hinging effect, inducing stress on the implants closest to the load application.[36] With excessively long distal cantilevers of FFP, there is always a risk of fracture of the prosthetic screw due to deformation of the framework.[37] Splinted tilted implants show lower stresses than the conventional/axial implant with cantilever and this reduction of the stress generated might help reduce maintenance problems of FFPs *vs* those that employ a conventional implant configuration.[32] Vertical load of the first tilted premolar is being shared by the two neighboring implants through the prosthesis, without the tilted implant being overloaded or bending.[38]

When stress patterns were compared in complete maxillary prosthesis supported by four or six implants in a long-term study by Silva et al,[39] no significant differences in implant survival were observed. The same authors also concluded that there was not much difference in stress location and distribution patterns in four and six implant models and that the cantilever should be as small as possible, as it increases stress on the distal implant, regardless of whether the prosthesis is supported by four or six implants.[39] In a study by Begg et al,[40] photoelastic strain patterns surrounding distal implants were analyzed placed at 0°, 15°, 30°, and 45° and authors concluded that increase in strain pattern was observed for 45° angled implants.[40]

An important concept here to discuss is the loading and its effect on micromotion in healing and healed bone, on which the foundations of All-on-4® concept are based, as it advocates immediate loading. According to Frost,[41] overloading and fracture occur more readily in a healing bone and so immediate loading may 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.[41] Immediately loaded implants osseointegrate, provided the forces acting on the implant and micromotion are controlled. However, Isidor[42] contradictorily stated that a slight load on healing bone shortens the healing time rather than prolonging it. But, if the occlusal force in humans is to be considered which is 800 N/cm[43] in the vertical component and around 20 N/cm in the lateral component,[44] the implants placed in soft bone or healing bone are at risk of developing a fibrous capsule if immediately loaded without splinting. These results are also in agreement with the data from Engelke et al.[45] A similar study showed that in type IV bone, lateral forces induced a micromotion between 100 and 250 mm, depending on the applied force.

Apart from micromotion, another clinical situation to be considered is that the entire framework is stable on just four implants which are embedded in soft bone. Even if one implant out of the four fails, the entire technique fails and the patient has to start from the beginning in a conventional manner by undergoing the process of bone augmentation again. This concept was basically created to immediately load or at least temporarise implants; however, many clinicians upload dentures after 1 to 2 months of implant placement, keeping the false notion of delayed loading or of not immediately loading the All-on-4®. Many clinicians have also misunderstood the concept of All-on-4®, and place implants not according to the protocol, but anywhere in the arch. However, such treatment planning is more practice and clinical acumen based rather than technique based, but many properly placed implants based on the All-on-4® concept which fail have not been reported in the literature.

CONCLUSION

Misch and Degidi[46] stated that majority of clinical reports on immediately loading and conventional two-stage loading healing approaches reveal similar survival rates in the completely edentulous patient; however, higher implant failure and greater crestal bone loss seem likely in the softer bone types but, as yet, are not reported in the literature, which can also be stated for the All-on-4®. So, before a patient can undergo All-on-4® treatment option, there are certain factors that should be taken into consideration based on clinical reality, such as:

- Type of bone
- Quality of bone
- Type of occlusion
- Affordability of the treatment
- Length of implants
- Clinical acumen

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