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An overview of the All-on-4™ implant philosophy

by Paulo Maló, Miguel de Araújo Nobre and Armando Lopes

The All-on-4™ implant approach for rehabilitation of edentulous jaws was developed at the Maló Clinic in the 1990s. Based on a concept of supporting a complete edentulous rehabilitation with four implants in immediate function, it was possible to resolve clinical situations that otherwise would need more complex/more expensive procedures.

The concept underwent continuous development from standard to extra-maxillary approaches, and its clinical documentation proved that it can be considered a viable treatment option for rehabilitating edentulous jaws. This article features the presentation of the concept, the inclusion/exclusion criteria and concept applications, clinical data, complications, remedies and challenges that will provide a general understanding of the All-on-4™ philosophy.

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Clinical rationale

The All-on-4™ concept is an immediate function rehabilitation protocol developed and performed in the private Maló Clinic, in Lisbon, Portugal. The All-on-4™ concept is based on the optimal number of four implants placed as cornerstones for supporting an edentulous jaw with a complete arch prosthesis. The concept benefits from posterior tilting of the two distal implants with a maximum of a two-teeth distal cantilever in the prosthesis, allowing the connection of a prosthesis on the same day as surgery.\(^1\)\(^2\)

The placement of axial implants in immediate function for complete edentulous rehabilitation has been demonstrated as a predictable rehabilitation procedure in the long term.\(^3\)\(^-\)\(^7\) However, the loss of posterior teeth, usually at an earlier age, leads to the loss of alveolar bone with pneumatization of the maxillary sinus in the maxilla and surfaces of mandibular dental nerve in the mandible, preventing immediate placement of implants in the posterior regions. An alternative could be the use of tilted implants, which allow maximum use of the existing bone with placement of posterior fixed teeth with minimum cantilever, in a region where bone height would not allow the placement of implants. The use of tilted implants is the key for this rehabilitation concept. Its use is supported as it allows for the implant support to be moved posteriorly\(^8\)\(^-\)\(^9\) and for the implant length to be enlarged.\(^2\)\(^6\)\(^7\) The implant follows a dense bone structure (the anterior wall of the maxillary sinus) and reaches high density bone in the anterior maxilla, enhancing the primary stability.\(^2\)\(^6\)\(^7\) The desired position of the implants is determined under the prosthetic point of view\(^7\) and there is a favourable inter-implant distance\(^7\) with cantilevers being as small as possible.\(^7\) Moreover, it is possible to conclude, using finite element analysis, that there is a biomechanical advantage in using splinted tilted distal implants rather than axial implants supporting distal cantilever units when comparing the coronal stress.\(^8\)

The All-on-4™ concept was designed to overcome patient anatomy limitations, providing fixed prosthetic solutions supported by immediate function implants for complete edentulous rehabilitations.

Inclusion/exclusion criteria and concept applications

Before surgery, the patient undergoes a medical history, clinical observation and complementary radiographic exams with orthopantomography (bone height) and computed tomography (CT) scan (bone width, bone height, anatomic structures and bone defects like cysts).
The height and width of the residual bone crest available between the anterior walls of the maxillary sinus for the maxilla, and between the mental foramina for the mandible, will establish the type of All-on-4™ surgical approach: All-on-4™ Standard, All-on-4™ Hybrid or All-on-4™ Double-Zygoma (Nobel Biocare®). The All-on-4™ Standard surgical protocol combines the use of two anterior implants placed in the axial position and two posterior implants tilted up to 45 degrees distally (in order to overcome patient anatomy limitations), following the maxillary anterior sinus wall in the maxilla, and the anterior loop of mandibular mental nerve in the mandible. For the mandible, the anatomical inclusion criterion is a bone ridge of 4mm width and ≥8mm height in the inter-foramina area (Figures 1 and 2). The mandible bone between the canines represents the mandible symphysis which is kept in the majority of edentulous jaws. For the edentulous maxilla, the anatomical aspects that must be taken into consideration should be the anterior wall of the sinus, the crest size and the midline. The anatomical inclusion criterion to rehabilitate with an All-on-4™ Maxilla standard technique is a bone ridge of a minimum of 4mm in width and ≥10mm height from canine to canine. The All-on-4™ concept can be used at different degrees of maxillary atrophy according to an edentulous classification, as the position of the posterior implant is the determining factor for the inter-implant distance. Depending on the degree of resorption, the posterior implant head will emerge at different positions at the bone crest, normally between the first molar (full bone volume, see Figure 3), the second premolar (moderate resorption, see Figure 4), and the first premolar (high resorption, see Figure 5). If the above criteria are not met, then an All-on-4™ Hybrid or All-on-4™ Double Zygoma should be considered. In the All-on-4™ Hybrid rehabilitation, maxillary anchored implants are used in conjunction with extra-maxillary anchorage implants (anchored in the zygomatic bone, see Figure 6), whereas in All-on-4™ Double Zygoma, only four extra-maxillary anchorage implants are used (Figures 7–10).
Fig 3 Orthopantomography representative of a patient with full bone volume from molar to molar rehabilitated through the All-on-4™ concept standard in the maxilla. Note the implants in positions #16, #13, #23, #26.

Fig 4 Orthopantomography representative of a patient with bone volume up to the second premolar (moderate resorption) rehabilitated through the All-on-4™ concept standard in the maxilla. Note the implants in positions #15, #12, #22, #25.

Fig 6 Orthopantomography representative of a patient rehabilitated through the All-on-4™ Hybrid (two standard implants and two extra-long implants anchored in the zygomatic bone).

Fig 7 Orthopantomography representative of a patient rehabilitated through the All-on-4™ Double Zygoma (four extra-long implants anchored in the zygomatic bone).

Fig 9 Occlusal view of an All-on-4™ Double Zygoma rehabilitation.

Fig 10 Patient smiling with an All-on-4™ Double Zygoma rehabilitation.
Advantages
The All-on-4™ surgical protocol allows fixed rehabilitation of edentulous patients without the use of complex surgeries for bone regeneration despite patient bone quantity. Compared with bone graft procedures, the All-on-4™ surgery is not only less invasive but also has lower morbidity and cost. Patients that previously could not be submitted to implant rehabilitation (involving maxillary reconstruction with bone graft) may benefit from this treatment. Through this technique, the rehabilitation of aesthetics and function can be achieved more quickly (in a few hours or even minutes after the surgery) and with higher success rates. Another implication of the findings was that they counteracted the ‘traditional’ recommendations of using additional implants to rehabilitate completely edentulous jaws (despite the lack of solid evidence for this, as identified in a meta-analytic study). One could infer from the results of Buytaert et al., who used the All-on-4™ concept for rehabilitating edentulous mandibles, that the need for additional implants when rehabilitating completely edentulous mandibles is questionable. The authors suggest the cost-effectiveness of inserting an increased number of implants when planning the rehabilitation of complete edentulous situations should be taken into consideration.

The All-on-4™ concept also allows a simplification of edentulous rehabilitation by avoiding the need of bone grafting, and consequently reducing costs to the patient significantly.

Clinical data
The All-on-4™ concept has been the subject of increasing scientific research investigations either on developing surgical guidelines in order to improve the surgical protocol or investigating the outcome of the rehabilitations. Regarding the development of surgical guidelines, Jensen et al. reported technical notes on the rehabilitation of atrophic maxillae (maxillary M-1 and mandibles (mandibular V-4), proposing the All-on-4™ technique as an alternative to bone graft or zygomatic implants for the same rehabilitation purpose. Also Jensen et al. reported on the usefulness of an osteotomy as a flat ‘shell’ on which to place the restoration, using this approach to enable optimal surgical prosthetic management of implant placement, to create prosthetic restorative space, or to establish maximum posterior spread of the implants. Geramipanah and Sadighpour reported on a previously investigated preoperative concept by Malo et al., called the ‘All-on-4™’ whereby solving a trigonometry equation, applied to an implant adjacent to a tilted implant (with the known length and angulation of the tilted implant), allows the safe distance or length of the non-tilted implant to be estimated.

Clinical studies performed by different authors provide information on the implant survival in the short, medium and long-term. In short-term outcomes the implant survival ranged from 94.8% to 99.7% in medium-term outcomes the survival rate was 96.7–100%, and for long-term outcomes the implant survival was 94.8% to 99.7% (Table 1). The incidence of biological and mechanical complications reported in the studies was generally low, with a higher incidence of mechanical complications reported by Agliardi et al. with 14% in prostheses fractures in one year, with Malo et al. reporting a 25% incidence of mechanical complications and a 13% incidence of biological complications within five years (Table 1).

The All-on-4™ concept can also be used with computerised planning and flapless implant surgery (NobelGuide® and Nobel Biocare®, see Figures 11-14). The implants’ positions are the same as for the flap procedure but fixture delivery is guided with a surgical template (NobelGuide® and Nobel Biocare®) based on a computer plan made in a 3D model of the patient’s jaw that is obtained from the axial cuts of a CT scan. A pre-surgery manufactured prosthesis is immediately delivered after
Fig 13 Intra-oral perioperative photograph illustrating the completion of the surgical phase of the All-on-4® rehabilitation using a flapless approach.

Fig 14 Patient smiling after being rehabilitated through the All-on-4® standard in the maxilla using a flapless approach and 3D planning.

<table>
<thead>
<tr>
<th>Studies</th>
<th>Jaw</th>
<th>Number of patients</th>
<th>Survival</th>
<th>Follow-up</th>
<th>Complications</th>
<th>Type of study</th>
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<tr>
<td>Maló et al²⁶</td>
<td>Maxilla</td>
<td>179</td>
<td>0.972</td>
<td>5y</td>
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<td>—</td>
<td>3y</td>
<td>—</td>
<td>Retrospective</td>
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<tr>
<td>Butura et al²⁷</td>
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<td>Babbush et al²⁷</td>
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<td>Pompers Puig⁴¹</td>
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<td>30</td>
<td>0.980</td>
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<td>1</td>
<td>1y</td>
<td>Low incidence</td>
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<td>173</td>
<td>Maxilla: 0.984; Mandible: 0.997</td>
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<td>2.5y</td>
<td>—</td>
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<td>—</td>
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<tr>
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<td>1</td>
<td>—</td>
<td>—</td>
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<tr>
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<td>1</td>
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<tr>
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<tr>
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<td>44</td>
<td>0.967-0.982</td>
<td>3y</td>
<td>Low incidence</td>
<td>Retrospective</td>
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Table 1 Clinical studies available in the literature concerning the All-on-4® concept.
surgery. Since no flap is reflected, the postoperative period is more comfortable with less pain and oedema. The results from a clinical study from Maló et al. investigating the outcome of rehabilitating completely edentulous patients through the All-on-4™ concept (Nobel Biocare®) using the Nobelguide (Nobel Biocare®) rendered implant survival rates of 97.2% for the maxilla and 100% for the mandible, with low incidence of complications after one year of follow-up. Based on these results this treatment modality was judged viable in the short-term outcome.

Analysing the results from several studies, it is possible to observe that the All-on-4™ concept renders high survival rates with low incidence of complications.

**Complications and remedies**

Most postoperative complications are related to temporary prosthesis overload. Surgical complications are uncommon. Slight to moderate swelling and bruises are normal, especially in the ten days following the procedure. Prosthesis fracture may occur as a result of overload or unstable occlusal contacts. When passive fit is not accomplished, the prosthesis will be more prone to fracture. Loosening of abutments is often related to occlusion instability, and is linked particularly to interferences during mandible lateral excursion movements. This problem should be dealt with as soon as possible and occlusion contacts must be corrected.

In the situation where one or more implants fail, there is the possibility of maintaining the prosthesis in function connected to two implants over a period of six months, and then re-inserting implants on the previously determined areas. By doing this, prosthetic failure is avoided and the patient can keep his or her prosthesis in function throughout the six month waiting period and the osseointegration period of the re-inserted implants.

**Challenges**

The All-on-4™ surgical protocol is still challenging, and today this challenge is most demonstrable, in terms of surgery, in the difficulty in achieving the necessary primary stability for immediate function in very low density jaws (Type IV) – especially in the maxilla. In some of these situations, despite favourable bone quantity, the use of under-preparation drilling sequence and the NobelSpeedy™ implant, it is still necessary to insert extramaxilla implants due to the bone quality. A new design of NobelSpeedy™ implant is being developed to overcome these situations.

Mandibles with very short thickness also represent a challenge. In these cases, a very thin and flat mandible body with less than 4mm width (from the crest to the inferior basal cortical) makes it impossible to place the implants. Usually, narrow platform NobelSpeedy™ implants are used in these mandibles, sometimes with bone fenestrations and dehiscences; however, without the relevant associated complications.

Concerning the atrophic maxilla, incorporating the NobelGuide™ protocol on the hybrid and double zygoma
rehabilitations will also present a challenge. Today, the software and the surgical components do not allow the necessary precision and safety to perform these surgeries but it is clear that this concept will meet both patients' and clinicians' needs in the future.

Conclusions

In conclusion, the All-on-4™ concept for total rehabilitation has proven to be clinically effective and with high survival rates in the short, medium and long-term outcomes. This concept is viable to resolve many situations where otherwise more complicated procedures would have been indicated. It is a standardised treatment procedure that can be used routinely in most patients in need of a complete edentulous rehabilitation and also adapts to further simplifications (such as Flapless surgery) based on computer planning (NobelGuide™, Nobel Biocare™).

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