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The All-on-Four Treatment Concept: A Narrative Review

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Abstract

Edentulism continues to pose a major rehabilitative challenge, particularly in patients with severely atrophic jaws where conventional implant placement is often precluded by insufficient bone volume. The All-On-Four treatment concept has emerged as a graftless alternative, using four strategically positioned implants; two placed axially in the anterior region and two tilted up to 45° posteriorly to support an immediate, full-arch fixed prosthesis while maximizing use of available native bone. This narrative review synthesizes current literature on the concept's evolution, surgical and prosthetic protocols, biomechanical principles, and long-term clinical performance, drawn from a structured search of PubMed/MEDLINE and the Cochrane Library. Since its formal introduction in the early 2000s, the protocol has been refined through variations such as the Hybrid and Quad-Zygoma approaches for cases with more extreme bone deficiency. Reported implant survival consistently exceeds 93% across follow-up periods extending beyond a decade, with marginal bone loss generally remaining within accepted biological limits. Mechanical complications, particularly denture-tooth fracture and screw loosening, are more common than biological ones, and their incidence is closely tied to cantilever length and prosthetic framework material. Patient-reported outcomes also favor the approach, showing marked gains in masticatory function and quality of life relative to conventional dentures. Despite this favorable evidence base, most supporting data derive from retrospective, single-center cohorts, underscoring the need for prospective, multicenter trials with extended follow-up. Overall, when guided by careful patient selection and prosthodontically driven planning, the All-On-Four concept offers a predictable, cost-effective solution for full-arch rehabilitation of the severely compromised edentulous arch.

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Introduction

Edentulism, defined as the complete loss of all dentition, remains a significant global public health concern. Complete edentulism was observed in 10.7% of the adult Indian population; however, the prevalence is higher among older persons (≥ 50 years) at 16.3%.^{1,2}

Conventional complete dentures are the most popular prosthetic therapy for edentulism, although attaining retention, stability and support remain challenging with severely resorbed ridges. Furthermore, restoration of partially edentulous atrophic posterior arches has proven to be problematic. Dental implants have emerged as a more favourable treatment option, providing better treatment outcomes and addressing the individualised needs of patients. There is a consensus that mandibular dentures retained by one or two implants show positive effects as compared to conventional complete dentures.³

Various implant treatment options, including implant-retained overdentures, the All-on-X concept (4–6 implants), traditional fixed implant bridges utilizing a larger number of implants (typically 6–10 or more per arch), and patient-specific implants, have emerged for full arch rehabilitation.⁴ However, treatment of individuals with significantly atrophic jaws remains one of the most difficult problems in implant dentistry. Sinus augmentation, ridge expansion, nerve transposition and bone grafts are typically necessary for the placement of traditional dental implants in atrophic jaws. The main drawback of these procedures is their technical complexity and increased risk of tissue and implant morbidity.⁵

The All-On-Four concept derives its name from its core principle: a full arch of prosthetic teeth supported by four strategically placed dental implants.⁵ This treatment concept was developed to maximise the use of available remnant bone in atrophic jaws, allowing immediate function and avoiding regenerative procedures.⁶ In recent times, clinicians expanded on this concept by including more than 4 implants in the implant-supported prosthesis, now denoted as All-on-X.⁷ In situations of severe bone loss and/or excessive maxillary sinus pneumatization, the All-On-Four concept's core principle is maintained by utilizing alternative approaches such as the All-On-Four Hybrid or All-On-Four quad zygoma protocols.

Methodology

This narrative review was conducted following a systematic electronic search of PubMed/MEDLINE and the Cochrane Library. The PubMed/MEDLINE search strategy employed the following Boolean string: ("atrophic maxilla"[Mesh] OR atrophic mandible OR "Jaw, Edentulous"[Mesh] OR "Alveolar Bone Loss"[Mesh] OR "Mouth, Edentulous"[Mesh] OR edentulous mandible) AND (fixed implant prosthesis OR immediate function OR full-arch fixed dental prostheses OR "Dental Implant-Abutment Design"[Mesh] OR All-on-4 OR All-On-Four OR tilted implants OR axial implants OR distal tilted implants) AND ("Immediate Dental Implant Loading"[Mesh] OR "Dental Implants"[Mesh] OR surgical protocol OR biological complication OR "Peri-Implantitis"[Mesh] OR peri-implant mucositis OR "Dental Restoration Failure"[Mesh] OR technical complication OR prosthetic fracture OR screw loosening). The Cochrane Library was searched for systematic reviews and meta-analyses using the terms "All-on-4", "full-arch implant prosthesis", "tilted implants", and "immediate implant loading".

The search covered articles published from January 2000 to the most recent available literature. Inclusion criteria encompassed clinical studies (prospective and retrospective), systematic reviews and meta-analyses, randomised controlled trials, finite element analyses, and consensus statements reporting on the All-On-Four treatment concept in fully edentulous or severely atrophic jaws. Reference lists of all included systematic reviews were hand-searched for relevant primary studies. Final reference selection was based on relevance to defined review objectives, methodological quality, and recency of publication.

History

The All-On-Four concept originally evolved from the work of Brånemark et al. in 1977 in which they used four to six vertically placed implants in anterior edentulous ridges to obtain full-arch fixed prosthesis.⁸ In 1999, Mattson et al. reported the use of four to six implants in the premaxilla to avoid sinus augmentation, successfully restoring patients

with fixed prostheses supporting twelve teeth.⁹ Subsequently, Krekmanov et al. (2000) and Aparicio et al. (2001) introduced the concept of extending implant-supported prostheses distally, which effectively reduced cantilever length without the need for complex surgical procedures.^{10,11} Kronstrom et al. (2003) employed a one-stage protocol with implants inclined at 30°, achieving a 93% implant survival rate after 12 months of follow-up.¹² The All-On-Four technique was popularized by Portuguese dentist and researcher Dr. Paulo Maló. In 2003, Maló et al. introduced the All-On-Four concept, emphasizing immediate loading in the mandible and standardising implant placement through the use of surgical guides.¹³ Two years later, in 2005, Maló et al. expanded the concept to the maxilla and demonstrated successful short-term clinical outcomes, further consolidating the All-On-Four approach as a predictable and innovative solution for full-arch rehabilitation.¹⁴ In parallel developments that extended the graftless rehabilitation concept to severely atrophic maxillae, Brånemark et al. reported long-term outcomes for zygomatic implants in 2004 while Duarte et al. proposed the immediately loaded Quad-Zygoma Protocol for edentulous maxillae in 2007.^{15,16}

Treatment Protocol

Clinical rationale:

In an All-On-Four procedure, two implants are placed vertically in the anterior region of the jaw, where bone density and quantity are typically higher. The remaining two implants are inserted at an angle of up to 45° in the posterior region.¹⁷ This angled placement serves multiple purposes: it maximises the use of available bone, reduces the need for bone grafting, and provides enhanced stability by increasing the implant-to-bone contact area.⁵ The desired position of the implants is determined under the prosthetic point of view and there is a favourable inter-implant distance with cantilevers being as small as possible. All four implants are rigidly splinted to enhance mechanical stability and reduce prosthetic complications.

Patient Evaluation:

A systematic preoperative evaluation involving necessary medical, anaesthetic and dental evaluation is required

before surgical treatment. Dental history such as history of teeth loss, bruxism and clenching should also be noted. Evaluation of vertical dimension of occlusion, smile line, lip support in the patient's existing denture or natural dentition is also recommended.¹⁸ In the case of maxillary arch rehabilitation, treatment is prescribed based on the availability and composite defect of bone in different zones of the maxilla: Zone I is the premaxilla, Zone II is the bicuspid zone, Zone III is the posterior maxilla.¹⁹ All-On-Four Standard is considered when bone is available in Zones I and II. All-On-Four Hybrid is selected when bone is available only in Zone I. All-On-Four Double-Zygoma is the treatment of choice when bone is unavailable in either of the zones. The height and width of the residual bone crest available between the mental foramina for the mandible will establish the type of All-On-Four surgical approach for the mandible.

In the All-On-Four Standard surgical protocol for the mandible, the anatomical inclusion criterion is a bone ridge of 4 mm width and greater than 8 mm height in the inter-foramina area. The height and width of the residual crest bone available between the anterior walls of the maxillary sinus for the maxilla will establish the type of All-On-Four surgical approach. The anatomical inclusion criterion to rehabilitate with an All-On-Four maxilla standard technique is a bone ridge of a minimum of 4 mm in width and greater than 10 mm height in the anterior maxilla with two axially placed anterior implants and two distally tilted implants angulated up to 45°.6

If the above criteria are not met, then an All-On-Four Hybrid or All-On-Four extra-maxilla should be considered. In the All-On-Four Hybrid rehabilitation, two maxillary anchored implants are used in conjunction with two zygomatic implants. Available bone in the premaxillary region should be greater than 10 mm in height and width between 3-5 mm. For All-On-Four Extra-Maxilla (quad-zygoma), only four zygomatic implants are used when less than 3 mm bone width and less than 10 mm bone height is available in the premaxillary region.

General Considerations

Primary implant stability must achieve a minimum insertion torque of 35 Ncm, with an optimal target of up to

45 Ncm, to permit immediate loading. A minimum bone width of 4 mm and height of 10 mm in the canine-to-canine region of the maxillary arch, and 8 mm in the mandibular interforaminal region, are required. Posterior implant angulation should not exceed 45° to optimise load distribution and limit cantilever length. Distal screw access holes for tilted posterior implants should emerge at the occlusal level of the first molar, second premolar, or first premolar.²⁰

Radiographic Evaluation

Panoramic radiographs and CBCT imaging are required to evaluate bone height, width, osseous pathology, arch shape, bone volume and bone density. Additionally, assessment of maxillary sinus, presence of sinus pathology for the maxilla and evaluation of inferior alveolar nerve position and its anterior loop for the mandible are also vital.²¹

Surgical Phase

The All-On-Four surgical protocol may be performed as conventional open-flap surgery or as a flapless guided surgery. 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 distal implants are positioned anterior to the mental foramen. This arrangement allows for good implant anchorage, short cantilever length, and large inter-implant distance. In the conventional surgery, a mucoperiosteal flap is elevated to expose the alveolar crest. An All-On-Four guide placed via a midline osteotomy assists in identifying optimal implant positions and angulations.⁶ Posterior osteotomies are prepared with the twist drill tilted to a maximum of 45°. Anterior sites are prepared at 0-17°, as far apart from each other as possible, allowing for a safe distance from the apex of the posterior implants. Multi-unit abutments are placed allowing for proper emergence of the prosthetic screw. When the minimum torque threshold of 35 Ncm cannot be achieved, a conventional healing period should be observed prior to prosthetic loading.^{22,23}

For guided surgery, implant placement is done by means of 3D diagnostics, digital treatment planning with a custom designed surgical template. Guided surgery supports

flapless or minimally invasive approaches and enables pre-operative fabrication of the provisional prosthesis, reducing intraoperative time and improving placement accuracy.

Prosthetic Phase

Conventional protocols employ abutment-level open tray impressions using polyvinyl siloxane, with multiunit impression copings splinted with acrylic resin to minimise distortion. Digital impressions employing scan bodies attached to multiunit abutments, intraoral scanners and photogrammetry have been increasingly adopted to streamline prosthetic protocols.²⁴

Immediate Prosthetic Protocol:

A provisional all-acrylic resin prosthesis is constructed and issued to the patient within a few hours of the surgery. Prosthetic screws are tightened to 15 Ncm.²² Recall appointments are scheduled at one week, three weeks, three months, and annually thereafter. Fabrication of the definitive prosthesis typically commences at the three-month review, following confirmation of osseointegration.²⁰

Definitive Prosthetic Protocol:

The definitive restorative solution is selected according to the patient's aesthetic requirements, occlusal load, and maintenance considerations, and may include:

1. Fixed prosthesis with Zirconia, Titanium, Base Metal Alloys or PEEK framework. Individual crowns are cemented to the final bridge framework, preferred for cases with the highest aesthetic demand and for patients who may have a need for potential localized crown replacement in the future.
2. Fixed prosthesis with metal/acrylic framework and acrylic teeth. This is a more affordable fixed option that provides a shock-absorbing, resilient material to reduce the impact force of dynamic occlusal loads, and is easier to repair as compared to porcelain.²³
3. Fixed prosthesis with metal or zirconia framework and composite or ceramic veneering. Ceramic is chosen for its high aesthetic demand and excellent colour stability (superior to acrylic or composite), with the

benefit of the underlying strength of a metal framework. Composite Veneering is used when there is a need for improved aesthetics over acrylic while still retaining easier repairability.

4. Removable final prosthesis: e.g. overdentures, indicated when there is a concern about limited patient dexterity or hygiene. It is also necessary for cases with a severe mucosal support requirement.¹⁸

Occlusal scheme for All-On-Four definitive prosthesis:

The recommended occlusal design incorporates simultaneous bilateral centric contacts on canines and posterior teeth, with light grazing contacts on anterior teeth in intercuspation; canine guidance in laterotrusive excursions when opposing natural dentition; group function when opposing an implant-supported posterior bridge; and relatively flat cusp morphology such that cusp inclinations remain below the inclination of the condylar path. When opposing a removable complete denture or overdenture, the most distal prosthetic tooth should be slightly out of occlusion with balancing contacts planned in excursions. 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.⁶

Biomechanical Considerations

Tilted Versus Axial Implants:

When an implant is part of a multi-implant supported prosthesis, the distribution of implants and the rigidity of the prosthesis help reduce bending of the implant. The more distally the posterior implant is tilted, the shorter the resulting cantilever and the lower the stress transmitted to that implant. Krekmanov et al. confirmed that tilted posterior implants produced survival rates and peri-implant bone levels comparable to axially placed implants, supporting the clinical validity of distal tilting.¹⁰ The systematic review and meta-analysis by Del Fabbro et al. found comparable survival rates and marginal bone loss for the maxilla over 5 to 13 years of follow-up and 93% in the mandible over a follow-up of 10 to 18 years.^{30,31} A retrospective analysis of 800 implants by Balshi et al. reported a 97.3% cumulative survival rate over a mean follow-up of approximately 3 years.³² A cohort study by

between tilted and axial implants in full-arch rehabilitations.²⁵

Immediate Loading and Osseointegration:

The All-On-Four concept is predicated on immediate prosthetic loading. Contemporary evidence supports that implants subjected to controlled loading can achieve osseointegration, provided that implant micromotion remains below accepted thresholds (typically 100–150 µm) and that the splinted prosthesis confers adequate rigidity to limit differential movement between implants.²⁶ Implant placement into fresh extraction sockets is feasible within the All-On-Four protocol and does not appear to adversely affect survival rates when total arch rehabilitation is undertaken with rigid prosthetic splinting, as confirmed in a five-year prospective study by Krennmair et al.²⁷

Anterior-Posterior Spread and Cantilever Length:

English proposed that posterior cantilever in mandibular implant-supported prosthesis should be 1.5 times the A-P-spread, whereas maxillary posterior cantilever should be reduced to 6-8 mm due to low bone density.²⁸ Recently, a 4-year clinical retrospective analysis by Drago indicated that for provisional prosthesis, cantilever length should not exceed one tooth size while the final prosthesis must have cantilever length/anterior posterior spread ratio less than 1.²⁹

Survival and Complication Rates

Implant Survival Rates

The clinical evidence on All-On-Four implant survival is substantial and generally favourable, though the quality of evidence across studies is heterogeneous, with a preponderance of retrospective single-centre cohorts and a relative paucity of randomised controlled trials or multi-centre prospective data.

The landmark longitudinal series by Maló et al. reported a cumulative implant survival rate of 94.7% Niedermaier et al. evaluating immediately loaded fixed full-arch dentures over up to 7 years documented implant survival rates ranging from 95.3% to 98.6% across maxillary and mandibular arches.³³ A 7-year retrospective cohort by Maló et al. confirmed consistent long-term

biological stability with a cumulative implant survival rate of 95.4% and a 5-year marginal bone loss of 1.81 mm.³⁴

Systematic reviews corroborate these findings. The meta-analysis by Del Fabbro et al. identified a pooled implant survival rate of 97.0% for full-arch rehabilitations supported by tilted and axially placed implants across follow-up periods ranging from 1 to 13 years.²⁵ The systematic review by Patzelt et al. similarly showed pooled survival rates above 95% across included studies.³⁵

Across studies, maxillary survival rates are consistently slightly lower than mandibular rates, attributable to the characteristically lower bone density and reduced cortical thickness of the atrophic maxilla. Marginal bone loss values observed across studies are generally within the accepted biological threshold of 1.0-1.5 mm at one year, with progressive but modest remodelling thereafter. Long-term data beyond 10 years remain confined to a small number of cohort studies, and additional prospective, multicentre, randomised studies with follow-up exceeding 10 years are needed to confirm the durability of these outcomes across diverse patient populations and implant systems.

Prosthetic Complications

Prosthetic complications are among the most frequently reported adverse events following All-On-Four rehabilitation and are predominantly mechanical. A retrospective analysis by Tallarico et al. with up to seven years of follow-up documented technical complications in a significant proportion of cases, with acrylic denture tooth fracture identified as the most common event, followed by prosthetic screw loosening and screw fracture.³⁶ Tironi et al. found that over a 5 to 14-year follow-up of 156 implants, prosthetic complications were predominantly related to denture tooth chipping and acrylic fracture in patients restored with metal-acrylic frameworks, while implant survival remained high at 97.4%.³⁷

Framework material selection significantly influences both the frequency and nature of prosthetic complications. Metal-acrylic frameworks are associated with higher rates of denture tooth fracture and wear, whereas monolithic zirconia frameworks offer greater fracture resistance but introduce higher manufacturing complexity and cost.¹⁸

Finite element analyses consistently demonstrate that framework stiffness and material elastic modulus influence stress distribution at the implant-abutment interface and at the crestal bone margin, and these parameters should be incorporated into material selection decisions.²⁶

Cantilever length remains a critical determinant of mechanical complication risk. Excessive cantilever extension amplifies bending moments at the most distal implants and increases the probability of screw loosening, framework fracture, and peri-implant marginal bone loss.²⁹ Clinicians should adhere to established cantilever-to-A-P spread ratio guidelines, specifically a ratio below 1.0 in the definitive prosthesis and should favour the shortest clinically acceptable cantilever.

Biological Complications

Peri-implant biological complications encompassing peri-implant mucositis and peri-implantitis have been reported in All-On-Four cohorts, though precise incidence rates are difficult to establish across studies due to heterogeneous diagnostic definitions and monitoring protocols. The comparative biological behaviour of axial and tilted implants has been specifically examined, with no statistically significant difference in marginal bone loss or implant success rates identified between the two orientations across multiple studies.²⁵

Cucchi et al. documented mean marginal bone loss of approximately 0.5 to 1.0 mm at three years in immediately loaded All-On-Four and All-on-six rehabilitations, values consistent with accepted biological stability thresholds.³⁸

Browaeys et al. documented ongoing crestal bone loss in a computer-guided, flaplessly placed All-On-Four cohort over three years, highlighting that even in optimised surgical conditions, long-term bone remodelling requires structured prospective monitoring.³⁹ The effect of systemic conditions on biological outcomes requires further study; however, existing evidence suggests that adequate control of systemic risk factors and rigorous personalised maintenance protocols can mitigate peri-implant disease risk in the All-On-Four setting.

Long-Term Outcomes

Long-term clinical data beyond 10 years are available from

a limited but growing number of cohort studies. A retrospective cohort by Agliardi et al. with 12 to 15 years of follow-up reported a cumulative implant survival rate of 97.51% in maxilla and 96.91% in mandible, a prosthetic survival rate of 93.6% with a slight reversal of the usual maxilla-mandible trend in this cohort. Mean marginal bone loss of 1.70 mm and 1.80 mm was seen in the maxilla and mandible respectively, suggesting durable long-term performance.⁴⁰

The most extended follow-up series currently available, a retrospective study by de Araújo Nobre et al. with 20 to 25 years of observation in mandibular All-On-Four rehabilitations reported implant and prosthetic survival rates that remained high at extreme follow-up durations, providing long-term evidence supporting the concept.⁴¹

The 10-to-18-year longitudinal series by Maló et al. confirmed a cumulative implant survival rate of 93% and a mean marginal bone loss of 1.7 mm, both within clinically acceptable parameters.³¹

Patient-Reported Outcomes

Patient-reported outcomes (PROs) are increasingly recognised as important measures of treatment success. A systematic review by Gonçalves et al. found significant and sustained improvements in oral health-related quality of life (OHRQoL) and patient satisfaction with All-On-Four rehabilitation compared with removable denture alternatives.⁴² Functional parameters including chewing efficiency and maximum bite force have been shown to be significantly superior with fixed All-On-Four prostheses compared with conventional complete dentures.⁵

Advantages

Tilted posterior implants avoid anatomical structures allowing placement of longer implants anchored in better quality bone.

1. Posterior cantilever length is reduced.
2. Eliminates/reduces the use of bone grafts.
3. Immediate function and fixed prosthetic rehabilitation are achievable.
4. Final restoration can be fixed or removable.
5. Reduced cost due to reduced number of implants.⁵

Limitations

1. Free hand surgical placement of implant may not always be possible as implant placement is completely prosthetically driven.
2. Length of cantilever in the prosthesis cannot be extended beyond a limit.
3. It is very technique sensitive and requires elaborate presurgical preparation.
4. Current evidence is dominated by retrospective single-centre studies; prospective randomised multicentre data with extended follow-up are limited.
5. In extremely atrophic mandibles with a buccolingual width of less than 4 mm, conventional All-On-Four implant placement may be impossible, necessitating alternative approaches.
6. The Hybrid and Quad Zygoma extensions of the protocol introduce additional technical complexity, learning curves, and surgical morbidity.⁴³

Conclusion

The All-On-Four treatment concept represents a well-documented approach to full-arch implant rehabilitation of the edentulous and severely atrophic jaw. The available literature consistently reports implant survival rates exceeding 93% at long-term follow-up, with clinically acceptable marginal bone levels, manageable prosthetic complication profiles, and significant improvements in patient-reported quality of life. These outcomes position the All-On-Four approach as a clinically viable and cost-effective alternative to conventional full-arch rehabilitation strategies that require extensive bone augmentation procedures.

Several areas require further research including the long-term biomechanical behaviour of the prosthesis-implant-bone system beyond 15 years, particularly the cumulative effects of cyclic occlusal loading on cortical bone, framework integrity, and prosthetic screw stability. The comparative performance of different framework materials over extended follow-up requires evaluation in prospective studies. Patient-reported outcomes, including functional, aesthetic, and psychosocial domains, should be incorporated as primary outcome measures in future trials, alongside standardised protocols for monitoring biological

complications and peri-implant disease. Finally, the application of digital workflows encompassing guided surgery, intraoral scanning, photogrammetry, and computer-aided design and manufacturing to the All-On-Four protocol warrants prospective investigation to validate accuracy, efficiency, and clinical outcome maintenance. When these conditions are met, the All-On-Four concept represents a predictable, clinically validated treatment option for the rehabilitation of the severely compromised edentulous arch.

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equivalence with established analogue techniques.

Optimal outcomes with the All-On-Four approach depend upon rigorous patient selection, prosthodontically driven treatment planning, meticulous surgical execution, adherence to immediate loading criteria, and structured long-term

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Disclosure

During the preparation of this manuscript, artificial intelligence based tool (Claude AI) were used for language refinement and grammar correction. All intellectual content, analysis, and conclusions were developed solely by the authors, who take full responsibility for the accuracy and originality of the work.

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