Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Long-term clinical outcomes of all-on-four immediate implant rehabilitation: a 10-year retrospective study

Hanqing Zhao
First Hospital of Shanxi Medical University
Yanjun Jiao
First Hospital of Shanxi Medical University
Liang Yan
First Hospital of Shanxi Medical University
Jue Wang
wang.jue@sydyy.com

First Hospital of Shanxi Medical University

Research Article

Keywords: All-on-4, Immediate implant rehabilitation, Edentulism, Marginal bone loss, Long-term follow-up

Posted Date: May 22nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9593519/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background:

Immediate implant rehabilitation with the all-on-four concept has been widely used for edentulous patients, but long-term data beyond 5 years are limited. This study aimed to evaluate the long-term clinical outcomes of the all-on-four immediate implant rehabilitation protocol in edentulous patients over a 10-year follow-up.

Methods:

This retrospective cohort study included 16 edentulous patients treated between September 2009 and September 2015, with 76 implants supporting 19 full-arch fixed prostheses. Immediate provisional restorations were delivered on the day of surgery, followed by definitive prostheses after 3–6 months. Patients were followed for up to 10 years. Outcomes included implant and prosthesis survival, marginal bone loss (MBL), modified plaque index (mPI), modified sulcus bleeding index (mSBI), Oral Health Impact Profile-14 (OHIP-14), and patient satisfaction.

Results:

Three implants failed during early healing, resulting in an implant survival rate of 96.05%, while prosthesis survival was 100%. Early MBL was greater in tilted implants than in axial implants ($P < 0.05$), but no significant differences were observed thereafter, with cumulative 10-year MBL of 1.80–1.88 mm. Both mPI and mSBI remained low, with no significant intergroup differences, and no peri-implantitis was observed. OHIP-14 scores and satisfaction levels indicated favorable patient-reported outcomes.

Conclusion:

The all-on-four protocol provides predictable long-term outcomes with high patient satisfaction. Optimization of primary stability, prosthetic design, and maintenance may further improve treatment predictability.

1. Background

In 2003, Maló et al. introduced the All-on-4 concept for immediate full-arch rehabilitation.[1] This protocol employs four strategically positioned implants to support a fixed prosthesis, avoiding critical anatomical structures and eliminating the need for bone grafting, with restoration delivered on the day of surgery. However, long-term evidence regarding the clinical performance and maintenance of this protocol remains limited.

The present study retrospectively evaluates All-on-4 cases treated in our department over the past decade, aiming to assess long-term clinical outcomes and patient-reported measures, and to provide clinically relevant evidence for implant rehabilitation.

2.Materials and methods

Study design and patient selection

This single-center retrospective cohort study included 16 edentulous patients who underwent All-on-4 rehabilitation between September 2009 and September 2015.A total of 76 implants supporting 19 full-arch fixed prostheses were analyzed. Among the patients, 3 presented with complete edentulism, 12 with mandibular edentulism, and 1 with maxillary edentulism. Patients were followed at approximately 6 months postoperatively and annually thereafter to assess long-term clinical outcomes.

Inclusion criteria

Patients were included if they met the following criteria:

(1) Complete maxillary or mandibular edentulism, or residual dentition deemed unrestorable, and eligibility for All-on-4 immediate function rehabilitation, with provision of written informed consent.

(2) No periodontal treatment within 3 months prior to prosthetic restoration, and no use of antibiotics or anticoagulant medications.

(3) Good general and oral health, with the ability to tolerate implant surgery.

Exclusion criteria

Patients were excluded if they met any of the following criteria:

(1) Uncontrolled systemic diseases, including uncontrolled diabetes mellitus or severe osteoporosis.

(2) Malignant tumors or a history of head and neck radiotherapy or systemic chemotherapy.

(3) Moderate to severe bruxism or clenching habits without effective occlusal splint management.

(4) Severe psychological or psychiatric disorders affecting the ability to maintain adequate oral hygiene.

Materials and instruments

Implants and prosthetic components were provided by the XIVE implant system (Dentsply Friadent, Germany) and the ITI implant system (Straumann, Switzerland).

Surgical and prosthetic procedures

All procedures were performed under local anesthesia. Residual roots and unrestorable teeth were extracted when necessary, followed by alveolar ridge recontouring and soft tissue management.

Implants were placed according to a standardized All-on-4 protocol, with posterior implants intentionally tilted to avoid anatomical structures and optimize biomechanical support.

Immediate provisional prostheses were delivered on the day of surgery. Definitive prosthetic rehabilitation was performed after 3–6 months, including titanium framework fabrication combined with resin prostheses or all-ceramic restorations.

Postoperative follow-up and data collection

Follow-up Protocol: Follow-up visits were scheduled at 1, 2, 4, and 8 weeks after immediate restoration, and every 2 months thereafter. After definitive prosthesis delivery, patients were followed every 6 months and annually.

Outcome measures:

(1) Implant and prosthetic complications

Implant survival and stability were recorded. Prosthetic complications included denture loosening, occlusal discrepancies, abutment screw loosening or fracture, fracture of the denture base, artificial tooth wear, and ceramic chipping (Fig. 1).

(2) Marginal bone loss (MBL)

Panoramic radiographs were obtained immediately after surgery, at 6 months, and annually thereafter. The implant–abutment junction was used as the reference point.

The vertical distance from the reference point to the most coronal bone-to-implant contact was measured on both mesial and distal aspects using ImageJ software.

MBL was calculated using the following formula:

$H = L \times h / l$

where L represents the actual implant length, l the radiographic implant length, and h the mean value of mesial and distal bone height measurements. All measurements were performed three times, and the mean value was used for analysis.

(3) Peri-implant soft tissue assessment

Plaque accumulation and bleeding on probing were evaluated. The modified Plaque Index (mPI) and modified Sulcus Bleeding Index (mSBI) were recorded. The occurrence of peri-implant mucositis and peri-implantitis was also documented.

(4) Oral health–related quality of life (OHIP-14)

At the 1-year follow-up after definitive prosthesis delivery, oral health–related quality of life was assessed using the Oral Health Impact Profile-14 (OHIP-14), covering seven domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap.

(5) Patient satisfaction

Patient satisfaction was assessed at the 1-year follow-up using a structured questionnaire. The evaluation included maintenance convenience, retention, masticatory efficiency, pronunciation, esthetics, comfort, overall satisfaction, and willingness to recommend the treatment.Each item was scored using a 5-point Likert scale (5 = very satisfied, 1 = very dissatisfied).

All clinical assessments were performed by calibrated examiners.

Statistical analysis

Statistical analyses were performed using SPSS software (version 29.0; IBM Corp., Armonk, NY, USA). Marginal bone loss (MBL) between axial and tilted implants was compared at each follow-up time point using Welch's independent samples t-test (two-tailed).

As the modified Plaque Index (mPI) and modified Sulcus Bleeding Index (mSBI) are ordinal variables (scores ranging from 0 to 3) and are not normally distributed, data were expressed as median (interquartile range, IQR). Intergroup comparisons were performed using the Mann–Whitney U test (two-tailed). A P value < 0.05 was considered statistically significant.

3. Results

Baseline characteristics of patients

Baseline characteristics of patients and implant-supported prostheses are summarized in *Table 1*.

Implant and prosthetic outcomes

Implant survival rate

Of the 76 implants placed, three failed during the early loading phase, resulting in an implant survival rate of 96.05%. The remaining 73 implants were functioning at the final follow-up.

All failed implants were located in the maxilla. Following removal of the failed implants, reimplantation was performed, and all reinserted implants remained stable throughout the subsequent follow-up period.

Prosthetic complications

Prosthetic complications were mainly mechanical in nature. Retention screw loosening occurred in five prostheses in two patients. Stability was restored after retightening. Chipping of all-ceramic crowns was observed in two patients with all-ceramic bridge restorations. After replacement of the prostheses, satisfactory function and stability were achieved during follow-up. Among the six patients treated with resin tooth restorations, three exhibited varying degrees of crown wear or damage.

Individual clinical events

One patient presented with cheek biting and posterior crossbite. Occlusion was corrected by resetting the teeth and fabricating a new prosthesis, after which satisfactory function was achieved.

Another patient with a maxillary All-on-4 restoration reported insufficient upper lip support, deepened nasolabial folds, and inadequate incisal display. These issues were corrected by increasing the labial thickness of the denture base and resetting the teeth during fabrication of the definitive prosthesis, resulting in improved esthetics and patient satisfaction.

Peri-implant marginal bone loss (MBL)

Changes in peri-implant marginal bone loss (MBL) between vertically placed and tilted implants during the 10-year follow-up period are presented in *Table 2*.

During the early follow-up period (≤2 years), MBL values were significantly higher in tilted implants than in vertically placed implants at several time points ($P < 0.05$). Specifically, mean MBL values for tilted implants exceeded those of vertical implants at ≤6 months, ≤1 year, and ≤2 years.

However, beyond 2 years, no statistically significant differences were observed between the two groups (all $P > 0.05$). Both groups exhibited a gradual increase in MBL over time, with similar long-term trends during the 5–10 years follow-up period.

Modified plaque index (mPI)

Changes in the modified plaque index (mPI) around implants during the 10-year follow-up period are presented in *Table 3*.

Overall, mPI values remained low and stable throughout the observation period. Median mPI scores for vertically placed anterior implants and tilted posterior implants were consistently 1, with interquartile ranges of 0–1 or 1–1. No statistically significant differences were observed between the two groups at any follow-up time point (all $P > 0.05$).

Modified sulcus bleeding index (mSBI)

Changes in the modified sulcus bleeding index (mSBI) are shown in *Table 4*.

Median mSBI values for both vertically placed anterior implants and tilted posterior implants were generally low throughout the follow-up period, with a slight increase over time. Median values ranged from 0 (IQR: 0–0) in the early period to 1 (IQR: 0–1) at later follow-up stages. No statistically significant differences were observed between the two groups at any follow-up time point (all $P > 0.05$). Peri-implant mucositis was observed in 40 implants in 7 patients (52.6%). All cases showed improvement following clinical management. No peri-implantitis was detected during the follow-up period.

Oral health impact profile-14 (OHIP-14)

The distribution of OHIP-14 scores is presented in *Table 5.* Overall, most patients reported a score of 0 ("never") across the majority of items, indicating favorable oral health–related quality of life following implant rehabilitation.

In the functional limitation domain, 3 patients reported mild speech impairment (Q1, score ≥1), whereas only 1 patient reported mild taste disturbance (Q2). In the physical pain domain, oral pain (Q3) showed relatively higher scores, with 14 patients reporting varying degrees of discomfort, predominantly scores of 1 or 2. In contrast, only 2 patients reported mild discomfort while eating (Q4).

Across the remaining domains—including psychological discomfort, physical disability, psychological disability, social disability, and handicap—most patients reported no or minimal impact.

Patient satisfaction

Patient satisfaction results are summarized in *Table 6***.** Overall satisfaction levels were high, with most responses concentrated at scores of 4 ("satisfied") and 5 ("very satisfied"). Retention, comfort, and overall satisfaction showed particularly favorable distributions, with the majority of patients reporting the highest score. Masticatory efficiency and pronunciation were also rated highly, although a small proportion of patients reported neutral responses.

In addition, patients reported concerns including postoperative discomfort, prolonged treatment duration, increased maintenance complexity, frequent follow-up visits, and higher treatment costs.

4. Discussion

Comparison of overall clinical outcomes with previous studies

This study evaluated long-term clinical outcomes of the All-on-4 protocol in 16 edentulous patients over a maximum follow-up period of 10 years, including 76 implants supporting 19 full-arch fixed prostheses. The overall implant survival rate was 96.05%, and the prosthesis survival rate was 100%.

These findings are consistent with those reported in landmark long-term studies of the All-on-4 concept. Maló et al. reported an implant survival rate of 94.8% and a prosthetic success rate of 99.2% in a 10-year mandibular study,[2] as well as a cumulative implant survival rate of approximately 93.9% in a 10–18-year

follow-up. [3] Similarly, Agliardi et al. reported 15-year cumulative implant survival rates of 97.51% in the maxilla and 96.91% in the mandible.[4]

Therefore, the outcomes of the present study fall within the range reported in international long-term studies, indicating that the All-on-4 immediate loading protocol provides predictable and stable long-term outcomes in the Chinese population. Importantly, long-term success depends not only on achieving adequate primary stability, but also on appropriate prosthetic design, occlusal management, and effective maintenance of oral hygiene.

Mechanisms and risk factors associated with early implant failure

In this study, three implants failed during the early healing phase, all located in the maxilla of the same patient at approximately 4 weeks postoperatively, consistent with the typical time frame of early osseointegration failure. Analysis of clinical data suggests that these failures were associated with multiple interacting factors.

First, insufficient primary stability played a critical role. The maxillary bone exhibited relatively low density, accompanied by labial bone plate defects, and the insertion torque did not reach the recommended threshold for immediate loading, indicating compromised mechanical stability.

Second, excessive early functional loading likely contributed to failure. The patient resumed heavy mastication prematurely due to the comfort of the provisional prosthesis and did not adhere to a soft diet. Previous studies have shown that a transient decrease in implant stability occurs during early bone remodeling, and excessive occlusal loading during this phase may increase micromotion and impair osseointegration.

Third, prosthetic design and load distribution may have influenced outcomes. Insufficient coverage of the provisional prosthesis base reduced its ability to distribute occlusal forces, resulting in stress concentration on implants and prosthetic components.

Finally, patient-related factors such as heavy smoking and poor oral hygiene likely exacerbated the risk. Smoking negatively affects bone healing and vascularization,[5] while inadequate prosthesis–tissue adaptation may promote food impaction and bacterial accumulation, creating an unfavorable microenvironment during early healing.

From a clinical perspective, stricter indications should be considered for immediate loading in maxillary All-on-4 cases. Preoperative assessment of bone quality and quantity is essential to ensure adequate primary stability. Postoperative instructions—including adherence to a soft diet and smoking cessation—should be emphasized. In cases where sufficient stability cannot be achieved, delayed loading, increasing the number of implants, or alternative surgical strategies should be considered.[6]

Spectrum of prosthetic complications and preventive strategies

The prosthetic complications observed in this study were mainly limited to screw loosening, ceramic chipping, and wear of resin teeth, consistent with mechanical complications reported in systematic reviews of long-term full-arch implant-supported restorations.

No catastrophic prosthetic fractures occurred, which may be attributed to appropriate occlusal management and prosthetic design strategies. During the provisional phase, lateral interferences were minimized, occlusal contacts were carefully controlled, and distal cantilevers were avoided to reduce early loading. In the definitive phase, occlusal forces were more evenly distributed by reducing posterior cusp inclination, controlling cantilever length, and ensuring passive fit of the prosthesis. These measures likely contributed to minimizing stress concentration and reducing the risk of fatigue-related complications.

In individual cases, complications such as cheek biting, speech difficulties, and insufficient facial soft tissue support were observed, highlighting the importance of individualized prosthetic design and comprehensive preoperative planning.

Temporal pattern of marginal bone loss (MBL) and implant angulation

This study demonstrated that marginal bone loss (MBL) in tilted implants was slightly greater than in vertically placed implants during the early postoperative period (≤2 years), with statistically significant differences at certain time points. However, these differences were no longer evident beyond 2 years, and both groups exhibited similar long-term trends, with cumulative 10-year MBL ranging from approximately 1.80 to 1.88 mm.

These findings are consistent with previous reports. Maló et al. reported 5-year, 10-year, and 15-year MBL values of 1.18 mm, 1.72 mm, and 2.32 mm, respectively,[3] while Agliardi et al. reported approximately 1.7 mm at 10 years.[4] In addition, systematic reviews and meta-analyses have demonstrated no significant differences in long-term MBL between tilted and axial implants.[7] Ernesto Bruschi, using CBCT to analyze changes in peri-implant marginal bone levels, found that compared with axial implants, tilted implants exhibited a statistically significant difference only in buccal peri-implant bone loss, with no other differences observed in terms of peri-implant bone loss, implant survival rate, or success rate.[8]

Therefore, the early differences observed in this study are more likely attributable to physiological bone remodeling and biomechanical adaptation rather than pathological bone loss. Clinically, these findings suggest that implant angulation alone should not be considered a determinant of long-term outcomes; instead, greater emphasis should be placed on load distribution and maintenance.

Peri-implant soft tissue health and the role of maintenance

The modified plaque index (mPI) remained low and stable throughout the 10-year follow-up, indicating good plaque control. Consistent with previous studies, plaque accumulation appears to be more strongly

influenced by patient compliance, prosthetic design, and maintenance protocols than by implant angulation alone.

The modified sulcus bleeding index (mSBI) showed a slight increase over time, and peri-implant mucositis was relatively common but reversible. This pattern aligns with findings from long-term studies, in which mucositis reflects inadequate plaque control rather than inevitable progression to peri-implantitis.[9]

These findings highlight that long-term success of full-arch implant-supported prostheses depends heavily on the establishment of a structured maintenance program, including regular follow-up visits, oral hygiene reinforcement, professional cleaning when necessary, and adjustment of prosthetic contours to maintain optimal tissue adaptation.[10]

Clinical significance of patient-reported outcomes

The OHIP-14 results demonstrated favorable oral health–related quality of life, and patient satisfaction scores were high across multiple domains, including retention, mastication, comfort, and overall satisfaction. These findings indicate that full-arch fixed implant rehabilitation provides substantial benefits in both functional restoration and psychosocial well-being.

However, patients also reported concerns related to cost, maintenance complexity, and follow-up frequency. These observations are consistent with previous reports describing full-arch fixed prostheses as a treatment modality with high clinical benefit but increased maintenance demands.

Therefore, clinicians should ensure thorough preoperative communication regarding long-term expectations and maintenance responsibilities, and establish individualized follow-up protocols.

Limitations and future directions

This study has several limitations, including a relatively small sample size, a single-center retrospective design, and the absence of a control group, which may limit the generalizability of the findings.

Future studies should adopt multicenter, prospective designs with larger sample sizes and incorporate advanced statistical approaches, such as mixed-effects models or generalized estimating equations (GEE), to account for clustering effects. In addition, standardized radiographic measurement protocols may further improve the reliability and comparability of long-term outcomes.

Declarations

Consent to Participate declaration

Written informed consent was obtained from all individual participants included in this study prior to enrollment and surgical treatment.

Consent to Publish declaration

The authors confirm that written informed consent for publication of the clinical data and images in this study was obtained from all participants.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Data Availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics declaration

This study was conducted in accordance with the ethical standards of the Helsinki Declaration. All patients signed a written informed consent form before surgery, acknowledging that they fully understood their rights and obligations. Postoperative follow-up data were collected with patients' informed consent, and all information was kept strictly confidential. All aspects of this study were formally approved by the Research Ethics Committee of First Hospital Shanxi Medical University (Ethics Approval Number:2009 GK031). Written informed consent was obtained from all individual participants included in this study prior to enrollment and surgical treatment. All patients were fully informed about the study purpose, procedures, potential risks, benefits, and their right to withdraw at any time without prejudice.

Author Contributions

Hanqing Zhao was primarily responsible for follow-up data collection and statistical analysis. Yanjun Jiao performed the All-on-4 surgical procedures. Liang Yan was responsible for the fabrication of prostheses. Jue Wang designed the study, performed the post-implantation prosthetic rehabilitation and follow-up examinations, and managed implant-related complications.

Fund Project

General Program of Natural Science Research in Shanxi Basic Research Plan (No. 202403021221286); Shanxi Returned Overseas Scholars Science and Education Innovation Project (No. 2025-052).

References

1. Maló P, Rangert B, Nobre M. All-on-four immediate-function concept with Branemark System implants for completely edentulous mandibles: a retrospective clinical study. *J Clin Implant Dent Relat Res.* 2003;5(suppl 1):2-9.

2. Maló P, de Araújo Nobre M, Lopes A, Moss SM, Molina GJ. A longitudinal study of the survival of all-on-4 implants in the mandible with up to 10 years of follow-up. *J Am Dent Assoc*. 2011; 142: 310-20.
3. Maló P, de Araújo Nobre M, Lopes A, Ferro A, Botto J. The all-on-4 treatment concept for the rehabilitation of the completely edentulous mandible: a longitudinal study with 10 to 18 years of follow-up. *Clin Implant Dent Relat Res*. 2019; 21: 565-77.
4. Agliardi EL, Pozzi A, Romeo D, Del Fabbro M. Clinical outcomes of full-arch immediate fixed prostheses supported by two axial and two tilted implants: a retrospective cohort study with 12-15 years of follow-up. *Clin Oral Implants Res*. 2023; 34: 351-66.
5. Stiller HL, Ionfrida J, Kämmerer PW, Walter C. The effects of smoking on dental implant failure: a current literature update. *Dent J (Basel)*. 2024; 12: 311.
6. Chen Y, Pu R, Xia Z, Yu K, Wang Y, Jiang Z, Yang G. Risk factors for implant failure of implant-supported fixed full-arch rehabilitation in edentulous maxillae and mandibles: a 1- to 7-year retrospective study. *J Dent*. 2025; 163: 106146.
7. Del Fabbro M, Pozzi A, Romeo D, de Araújo Nobre M, Agliardi E. Outcomes of fixed full-arch rehabilitations supported by tilted and axially placed implants: a systematic review and meta-analysis. *Int J Oral Maxillofac Implants*. 2022; 37: 1003-25.
8. Bruschi E, Manicone PF, De Angelis P, Papetti L, Pastorino R, D'Addona A. Comparison of marginal bone loss around axial and tilted implants: a retrospective CBCT analysis of up to 24 months. *Int J Periodontics Restorative Dent*. 2019; 39: 675-84.
9. Reis INRD, Huamán-Mendoza AA, Ramadan D, Honório HM, Naenni N, Romito GA, et al. The prevalence of peri-implant mucositis and peri-implantitis based on the world workshop criteria: a systematic review and meta-analysis. *J Dent*. 2025; 160: 105914.
10. Ramanauskaite A, Galarraga-Vinueza ME, Obreja K, Sader R, Schwarz F. Prevalence of peri-implant diseases in patients with full-arch implant-supported restorations: a systematic review. *Int J Prosthodont*. 2021;34(suppl): s27-45.

Tables

Table 1. Baseline characteristics of patients and implant prostheses

Parameters	Number (n)
Male/Female	9/7
Maxillary implants/Mandibular implants	16/60
XIVE implants/ITI implants	56/20
All-ceramic restorations/Resin tooth restorations	10/6

Table 2. Peri-implant marginal bone loss (MBL) of vertical and tilted implants at different follow-up time points

Follow-up Time	Patients / Implants	Vertical Implants (Mean ± SD, mm)	Tilted Implants (Mean ± SD, mm)	P value
≤ 6 months	16 / 76	0.41 ± 0.08	0.45 ± 0.12	0.045
≤ 1 year	16 / 76	0.71 ± 0.11	0.85 ± 0.19	0.001
≤ 2 years	16 / 76	0.82 ± 0.23	0.96 ± 0.35	0.028
≤ 3 years	16 / 76	1.06 ± 0.36	1.11 ± 0.37	0.27
≤ 4 years	15 / 72	1.20 ± 0.33	1.22 ± 0.29	0.74
≤ 5 years	15 / 72	1.38 ± 0.34	1.43 ± 0.33	0.48
≤ 6 years	15 / 72	1.45 ± 0.24	1.52 ± 0.31	0.19
≤ 7 years	15 / 72	1.49 ± 0.26	1.58 ± 0.23	0.082
≤ 8 years	14 / 68	1.55 ± 0.22	1.63 ± 0.25	0.14
≤ 9 years	13 / 64	1.71 ± 0.28	1.73 ± 0.27	0.76
≤ 10 years	12 / 60	1.80 ± 0.21	1.88 ± 0.29	0.16

Table 3. Comparison of modified plaque index (mPI) between vertical anterior implants and tilted posterior implants at different follow-up time points

Follow-up Time	Patients / Implants	Vertical Implants (0/1/2/3)	Median (IQR)	Tilted Implants (0/1/2/3)	Median (IQR)	P value
≤ 6 months	16 / 76	20/18/0/0	1 (0–1)	18/20/0/0	1 (0–1)	0.63
≤ 1 year	16 / 76	18/20/0/0	1 (0–1)	16/22/0/0	1 (0–1)	0.48
≤ 2 years	16 / 76	16/22/0/0	1 (0–1)	14/24/0/0	1 (0–1)	0.41
≤ 3 years	16 / 76	14/24/0/0	1 (0–1)	14/24/0/0	1 (0–1)	1.00
≤ 4 years	15 / 72	12/22/2/0	1 (0–1)	12/22/2/0	1 (0–1)	1.00
≤ 5 years	15 / 72	12/22/2/0	1 (0–1)	10/22/4/0	1 (0–1)	0.39
≤ 6 years	15 / 72	10/22/4/0	1 (0–1)	8/24/4/0	1 (0–1)	0.41
≤ 7 years	15 / 72	8/24/4/0	1 (0–1)	6/26/4/0	1 (0–1)	0.48
≤ 8 years	14 / 68	4/26/4/0	1 (0–1)	2/28/4/0	1 (0–1)	0.55
≤ 9 years	13 / 64	2/28/2/0	1 (1–1)	2/28/2/0	1 (1–1)	1.00
≤ 10 years	12 / 60	0/28/2/0	1 (1–1)	0/28/2/0	1 (1–1)	1.00

Note: mPI = modified plaque index. Data are presented per implant; 0/1/2/3 indicate the number of implants with corresponding scores. Intergroup comparisons were performed using the Mann–Whitney U test.

Table 4. Comparison of modified sulcus bleeding index (mSBI) between vertical anterior implants and tilted posterior implants at different follow-up time points

Follow-up Time	Patients / Implants	Vertical Implants (0/1/2/3)	Median (IQR)	Tilted Implants (0/1/2/3)	Median (IQR)	P value
≤ 6 months	16 / 76	32/6/0/0	0 (0–0)	32/6/0/0	0 (0–0)	1.000
≤ 1 year	16 / 76	30/8/0/0	0 (0–0)	30/8/0/0	0 (0–0)	1.000
≤ 2 years	16 / 76	28/10/0/0	0 (0–1)	27/11/0/0	0 (0–1)	0.804
≤ 3 years	16 / 76	28/10/0/0	0 (0–1)	26/12/0/0	0 (0–1)	0.620
≤ 4 years	15 / 72	26/10/0/0	0 (0–1)	25/10/1/0	0 (0–1)	0.748
≤ 5 years	15 / 72	24/11/1/0	0 (0–1)	22/12/2/0	0 (0–1)	0.587
≤ 6 years	15 / 72	20/15/1/0	0 (0–1)	20/14/2/0	0 (0–1)	0.923
≤ 7 years	15 / 72	18/16/2/0	0.5 (0–1)	16/18/2/0	1 (0–1)	0.671
≤ 8 years	14 / 68	17/14/3/0	0.5 (0–1)	14/16/4/0	1 (0–1)	0.460
≤ 9 years	13 / 64	12/16/4/0	1 (0–1)	10/18/4/0	1 (0–1)	0.681
≤ 10 years	12 / 60	10/18/2/0	1 (0–1)	10/18/2/0	1 (0–1)	1.000

Note: mSBI = modified sulcus bleeding index. Data are presented per implant; 0/1/2/3 indicate the number of implants with corresponding scores. Intergroup comparisons were performed using the Mann–Whitney U test.

Table 5. Distribution of Oral health impact profile-14 (OHIP-14)scores

Dimension	Item No.	Item Content	Score Distribution (n, 0/1/2/3/4)
Functional Limitation	Q1	Speech impairment	13/2/1/0/0
	Q2	Taste deterioration	15/1/0/0/0
Physical Pain	Q3	Oral pain	2/10/4/0/0
	Q4	Discomfort while eating	14/2/0/0/0
Psychological Discomfort	Q5	Feeling self-conscious	15/1/0/0/0
	Q6	Feeling nervous	15/1/0/0/0
Physical Disability	Q7	Diet restriction	14/2/0/0/0
	Q8	Interrupted meals	15/1/0/0/0
Psychological Disability	Q9	Difficulty relaxing	15/1/0/0/0
	Q10	Feeling embarrassed	15/1/0/0/0
Social Disability	Q11	Irritability towards others	15/1/0/0/0
	Q12	Impaired daily work	15/1/0/0/0
Handicap	Q13	Reduced life satisfaction	16/0/0/0/0
	Q14	Limited life ability	16/0/0/0/0

Note: 0 = never; 1 = hardly ever; 2 = occasionally; 3 = frequently; 4 = always.

Table 6. Distribution of patient satisfaction scores

Survey Item	Score Distribution (n, 5/4/3/2/1)
Retention	14/2/0/0/0
Masticatory efficiency	12/3/1/0/0
Pronunciation	13/2/1/0/0
Comfort	14/2/0/0/0
Overall satisfaction	14/2/0/0/0
Willingness to recommend	13/2/1/0/0

Note: 5 = very satisfied; 4 = satisfied; 3 = neutral; 2 = dissatisfied; 1 = very dissatisfied.

Figures

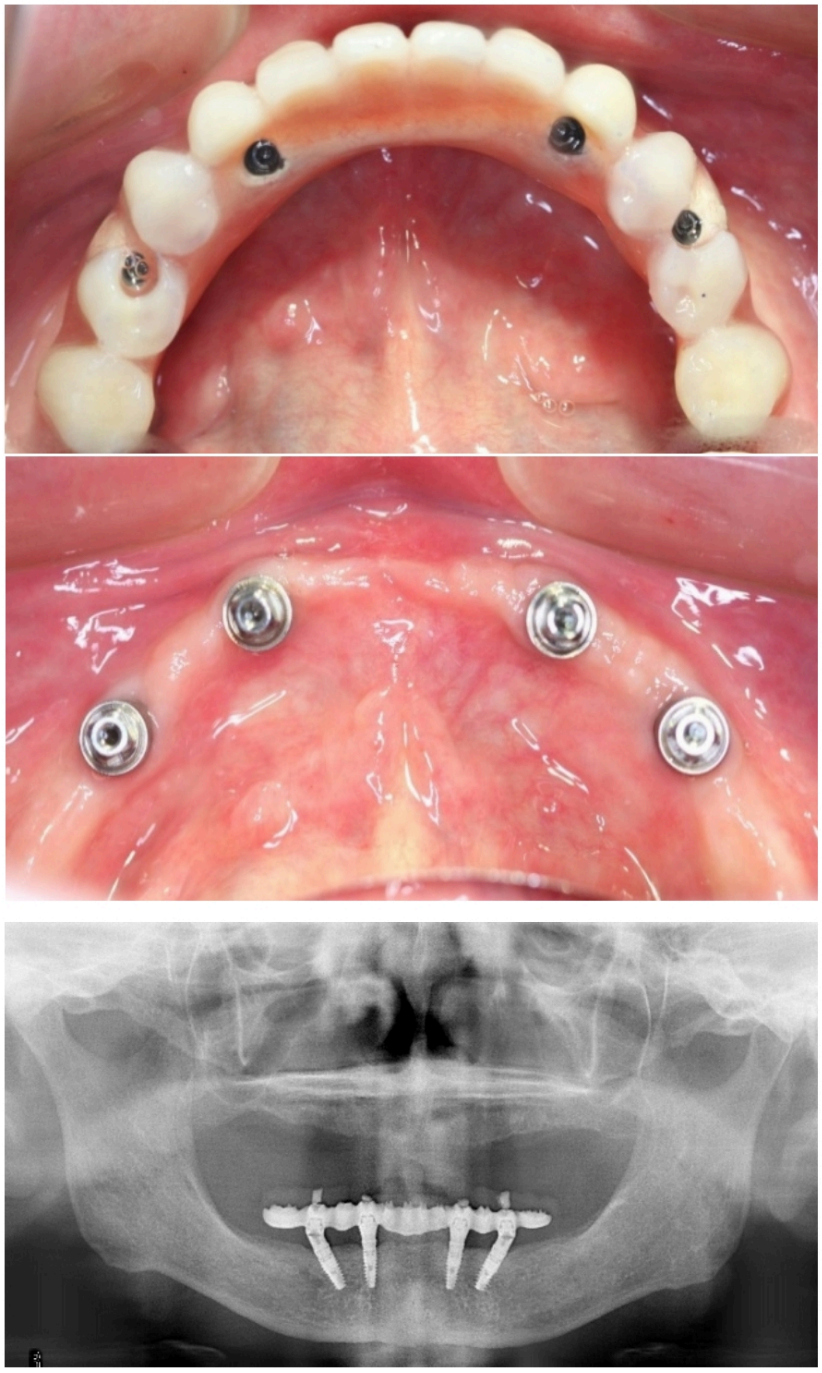


Figure 1

Re-examination for mandibular All-on-4 Patient