

# The All-on-Four Implant Therapy Protocol in the Management of Edentulous Chinese Patients

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**Purpose:** To evaluate the outcome and special characteristics of immediate implant rehabilitation using the All-on-Four treatment concept in completely or potentially completely edentulous Chinese patients. **Materials and Methods:** A convenience sample consisted of 69 consecutive patients (37 men, 32 women; mean age: 56.7 years) treated with immediate implant placement and full-arch prosthodontic provisional prostheses between April 2008 and December 2011. Of 344 implants (192 mandibular, 152 maxillary), 240 implants were placed in fresh extraction sites. The remaining 104 implants were placed in healed sites. Implants were immediately loaded with a fixed full-arch provisional prosthesis. Implant survival rate, marginal bone loss, abutment selection, complications, and subjective patient responses were recorded during follow-up. **Results:** Implant survival rate was 96.2% at 33.7 months of mean follow-up (range: 12 to 56 months). A statistically significantly higher implant survival rate was found in the mandible (99.0% vs 92.8%) ( $P < .05$ ). No significant difference existed between survival rates for implants placed in postextraction sites and healed sites ( $P > .05$ ). Peri-implant marginal bone loss around upright implants and tilted implants was  $0.7 \pm 0.2$  mm and  $0.8 \pm 0.4$  mm, respectively. All patients reported satisfactory treatment outcomes. **Conclusions:** The modified All-on-Four treatment concept provides predictably favorable outcomes in completely or potentially completely edentulous patients and is well suited to the sociodemographic needs of Chinese patients. Exploratory use of a surgical guide was limited because of mouth opening, and more angulated abutments were needed in anterior upright implants of the maxilla. *Int J Prosthodont* 2013;26:509–516. doi: 10.11607/ijp.3602

Immediate loading of implant-supported full-arch prostheses in either arch is a popular procedure that provides excellent implant survival rates as reported by European and North American researchers.<sup>1–4</sup> The cumulative implant survival rate for one particular protocol—the so-called All-on-Four concept—is reported to range from 92.2% to 100%.<sup>3,5</sup>

The All-on-Four treatment can be prescribed to both currently edentulous patients and patients with terminal dentition. This treatment concept involves a single-unit full-arch fixed provisional prosthesis supported by four implants, two anterior upright and two tilted posterior implants, and is used with immediate loading.

Tilted implants have been shown to generate better biomechanic responses<sup>6</sup> and in a meta-analysis to have no significant difference in either failure rate compared with upright implants<sup>7</sup> or marginal bone loss.<sup>8</sup> A shorter cantilever when using four tilted implants has been shown to decrease stress on peri-implant cortical bone.<sup>9,10</sup> Tilted implants offer several advantages, such as the use of extra-long implants, reduced or eliminated cantilever length, and avoidance of vulnerable anatomical sites, eg, the maxillary sinuses and nerve canals.<sup>3,10</sup>

The treatment concept is a practical and attractive approach for routine use in countries with large populations and limited dental care availability. However, relevant published data reflecting comprehensive geographic endorsement of the technique's efficacy remain unavailable.

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**Table 1** Distribution of Patients and Implants

Age (y)	Men	Women	Edentulous maxilla	Dentate	Edentulous mandible	Dentate	Arches	Implants
< 40	0	3	2	1	1	1	5	20
41-50	8	7	1	7	4	9	21	84
51-60	13	13	4	11	4	11	30	120
61-70	13	6	3	8	4	9	24	96
> 70	3	3	0	1	3	2	6	24
Total	37	32	10	28	16	32	86	344

**Table 2** Inclusion and Exclusion Criteria**Inclusion criteria**

1. Age  $\geq$  18 y
2. Patients in general good health: physically and psychologically able to undergo implant surgery and restorative procedures
3. Residual bone volume for implant placement  $\geq$  4-mm wide and  $\geq$  10-mm long
4. Implants able to be seated with a final insertion torque of  $\geq$  35 Ncm

**Exclusion criteria**

1. Severe bruxism or clenching habits
2. Presence of active infection or inflammation
3. Irradiation in the head or neck region within preceding 12 mo
4. Poor oral hygiene and poor motivation to initiate/maintain good oral hygiene
5. Heavy smoker (daily consumption > 20 cigarettes)
6. Inability to return for follow-up visits

This study evaluated the initial efficacy and short-term outcome of the All-on-Four treatment concept on Chinese patients who were already edentulous or whose treatment plan included the removal of the remaining terminal dentition.

## Materials and Methods

### Patients

This study was performed in the Department of Implant Dentistry, Peking University School of Stomatology, from April 2008 to December 2011. Sixty-nine consecutive patients (37 men, 32 women) with a mean age of 56.7 years (range: 37 to 74 years) were included. A total of 86 arches, including 26 completely edentulous arches and 60 dentate arches with terminal dentition, were treated according to the All-on-Four concept (Table 1).

All patients were informed of the purpose of the study, associated details, and alternative treatments, eg, complete dentures, and written consent was obtained from each patient before the start of treatment.

This study was approved by the Beijing Municipal Health Bureau (no. 2008-99). The inclusion and exclusion criteria employed are listed in Table 2.

### Implant Components

A total of 344 implants were inserted: 52 Brånemark Mk III and 292 NobelSpeedy Groovy (TiUnite, Nobel Biocare). All implants achieved a final insertion torque of at least 35 Ncm. The length of the implants ranged from 10 to 18 mm. One hundred thirteen straight abutments and 231 angulated multiunit abutments were used, including 59 angulated abutments (Nobel Biocare) used in 76 upright anterior maxillary implants (77.6%).

### Preoperative Evaluation

All patients underwent intraoral and extraoral clinical evaluation prior to implant surgery. Clinical examinations included arch shape and size, maxillomandibular relationship, smile lines, and lip support. A panoramic radiograph was taken to evaluate bone volume and density, and to identify relevant anatomical structures. Cone beam computed tomographic (CBCT) scans were taken when judged to be necessary to enhance radiographic anatomical assessments (Figs 1 and 2).

### Surgical Procedure

Antibiotic prophylaxis (cefuroxime axetil tablets, 250 mg) was administered before surgery and for 3 days postoperatively. Three 1-minute oral rinses with 0.2% chlorhexidine were performed 30 minutes before surgery. Surgical procedures were performed under local anesthesia: articaine hydrochloride and epinephrine tartrate injection (Dentaires Pierre Rolland).

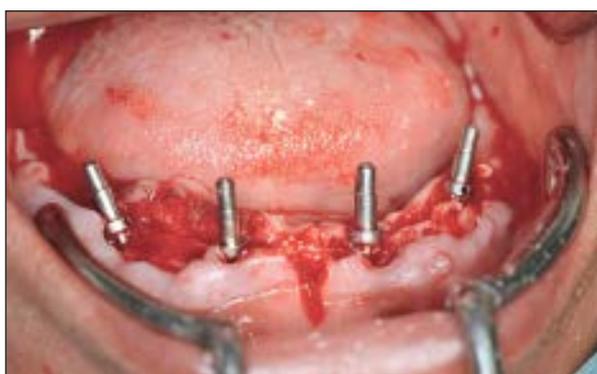
The implants were inserted according to the manufacturer's guidelines. Compromised teeth with an unfavorable prognosis (severe periodontal or endodontic lesions) were extracted, and the fresh extraction



**Fig 1** Preoperative clinical view.



**Fig 2** Preoperative panoramic radiograph.



**Fig 3** Implant position indication.



**Fig 4** Implant placement.

sockets were carefully debrided. The ridge crest was trimmed to remove any sharp edges. The two axially anterior implants were placed in the anterior area parallel to the midline following the maxilla axially to avoid buccal bone plate penetration. If buccal penetration occurred, then the guided bone regeneration technique was used. A small window was opened for identification of the exact position of the sinus anterior wall. The two posterior implants were inserted and tilted no more than 45 degrees relative to the occlusal plane.

In the mandible, the anterior loop of the mental neurovascular bundle was used to determine the positioning of the posterior tilted implants. The mandibular implant platform was positioned at bone level.

In cases where the tilted implant was inserted where the mesial bone level was higher than the distal site, the mesial bone was reduced using a bone mill to ensure that the abutment was completely in position.

Straight or angulated (17- or 30-degree) abutments were used as a necessary common insertion path. Flaps were closed and secured with a 4-0 absorbable suture (Monocryl or Vicryl, Johnson & Johnson). A panoramic radiograph was obtained immediately after implant surgery (Figs 3 and 4).

### ***Prosthetic Procedure***

After implant surgery, impression transfer copings were fastened to the abutments with screws and the copings were connected together with composite resin materials (DMG). The impression was taken with silicone impression material (DMG) using the pick-up technique. After removal of the impression transfer coping, vertical dimension and bite registration were taken. Provisional complete arch all-acrylic prostheses without metal frameworks were manufactured at the dental laboratory and delivered to the patients approximately 6 hours after implant placement. The provisional prosthesis consisted of 10 to 12 units based on the posterior implant position. The cantilever length was no more than 8 mm. The centric and lateral contacts were assessed with 40- $\mu$ m articulating paper (Bausch) and adjusted as necessary. A soft diet was recommended for 2 months after implant placement and all patients were educated on oral hygiene (Figs 5 to 7).

Six months post-implant placement, in the absence of pain and inflammatory signs, the panoramic radiographs indicated no radiolucency around the



**Fig 5** Fixed provisional prosthesis in the mandible.



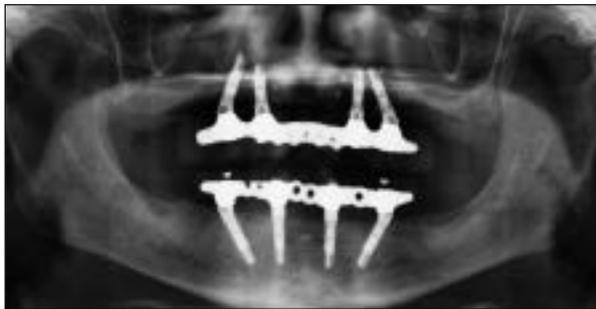
**Fig 6** Implant placement in the maxilla.



**Fig 7** Fixed provisional prosthesis in the maxilla.



**Fig 8** Definitive prosthesis.



**Fig 9** Postoperative radiograph at 1 year.

implants, and the definitive prosthesis was delivered. The final prosthesis was composed of 12 acrylic resin teeth units with a metal framework (Figs 8 and 9).

### **Outcome Measures**

Treatment outcome measures included the following parameters.

**Implant survival rate.** The implant criteria used to determine implant survival included (1) absence of any radiolucency around an implant; (2) absence of any signs of infection, pain, or ongoing pathologic processes at the implant site; and (3) the implant had been restored and was functionally loaded.

**Marginal bone level changes.** Baseline levels using panoramic radiographs were established at the time of surgical intervention. The implant-abutment interface was taken as a reference point for the bone level measurements. Follow-up examinations were performed 3, 6, and 12 months after implant placement and on an annual basis thereafter. Mesial and distal marginal bone changes of implants were measured at 1 year after implant placement using Planmeca Romexis software (Planmeca Dental Imaging Oy) with an accuracy of 0.1 mm.

**Prosthesis success.** The prosthesis was considered a failure if it was not possible to place it as planned or its function was compromised due to implant failure.

**Complications and abutment stability.** Complications were divided into biologic and mechanical complications. The former included sinus membrane perforation, peri-implant mucositis, fistulas, etc. Prosthetic mechanical complications included loose screw, prosthesis fracture, artificial teeth separation from the restoration acrylic resin base, etc.

**Patient satisfaction.** Each patient's response to the treatment outcome in the context of function, esthetics, and phonetics was assessed via a

**Table 3** Implant Observation Period Distribution

Time (mo)	Maxilla	Mandible	Implants
Loading-12	6	7	52
12-24	3	2	20
24-36	11	13	96
36-48	15	22	148
48-56	3	4	28
Total	38	48	344

questionnaire administered at the 6- and 12- month recall visits. The scoring for each subject was as follows: 5 = excellent, 4 = very good, 3 = good, 2 = sufficient, and 1 = poor.

### Follow-up and Maintenance

The first control visit of the patient was scheduled 1 week after immediate loading. Further follow-up visits were scheduled every 3 to 6 months for the first year and on an annual basis thereafter, for up to 5 years (Table 3).

### Statistics

The implant cumulative survival rate, based on all of the inserted implants, was evaluated using survival analysis. Statistical analysis was done using SPSS version 16.0 statistical software (IBM) using a log rank test to determine the level of significance ( $P < .05$ ) comparing implant survival rates.

## Results

All 344 implants achieved initial stability with over 35-Ncm insertion torque. However, three anterior maxillary implants had approximately 3-mm penetration of the buccal bone plate and require guided bone regeneration. All patients could be rehabilitated according to the All-on-Four concept and were followed up for at least 1 year. The range of follow-up was from 12 to 56 months (mean: 33.7 months). One patient dropped out after his 36-month visit due to unrelated mortality. The other 68 patients completed their study recall as planned.

### Implant Survival Rate

The overall implant survival rate was 96.2% (99.0% in the mandible and 92.8% in the maxilla). Table 3 shows the implant observation period distribution.

**Table 4** Life Table Analysis for the Mandible

Interval (mo)	Arches	Implants	Upright	Tilted	Failure	CSR (%)
Loading-2	48	192	96	96	0	100
2-12	6	192	95	95	2	99.0
12-24	2	168	84	84	0	99.0
24-36	14	160	80	80	0	99.0
36-48	22	104	52	52	0	99.0
48-56	4	16	8	8	0	99.0

CSR = cumulative survival rate.

**Table 5** Life Table Analysis for the Maxilla

Interval (mo)	Arches	Implants	Upright	Tilted	Failure	CSR (%)
Loading-2	38	152	76	76	0	100
2-12	6	148	12	12	11	92.8
12-24	3	128	6	6	0	92.8
24-36	10	112	20	20	0	92.8
36-48	15	72	30	30	0	92.8
48-56	4	16	8	8	0	92.8

CSR = cumulative survival rate.

The implant survival rate was significantly elevated in mandibular versus maxillary implants (Tables 4 and 5).

No significant difference was observed between survival rates of postextraction implants and healed-site implants (Table 6, Fig 10).

### Marginal Bone Level Changes

Marginal bone level changes were statistically similar on the upright implants ( $0.7 \pm 0.2$  mm) and the tilted implants ( $0.8 \pm 0.4$  mm) ( $P > .05$ ).

### Prosthesis Survival Rate

Three fixed prosthesis were changed to removable dentures until new implants could be placed in 2 to 3 months, and fixed prostheses were again immediately placed because two implants were lost on the same side in three patients. The prosthesis success rate was 96.5%.

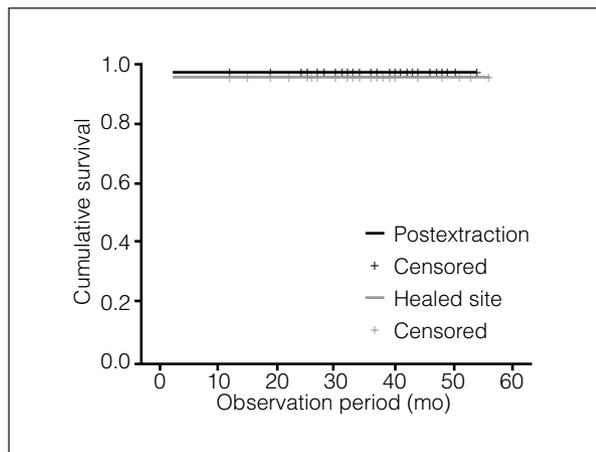
### Complications

Surgically, a total of 13 implants failed, including 11 posterior implants (10 maxillary, 1 mandibular) and 2 anterior implants (1 maxillary, 1 mandibular). All implant failures occurred at 8 to 10 weeks after placement. No biologic complications occurred.

**Table 6** Overall Comparisons\*

	Chi-square	df	P
Log rank (Mantel-Cox)	.432	1	.511

\*Test of equality of survival distributions for the different levels of postextraction-site and healed-site implants.



**Fig 10** Implant survival rates for postextraction-site implants and healed-site implants.

Three abutment screws loosened and five artificial teeth separated from the acrylic resin base. Fracture occurred near the implant metal coping in three provisional restorations. No fracture occurred near the cantilever area.

### Patient Satisfaction

All patients were satisfied with the function and esthetic aspects of their prostheses (an excellent rating for 95.6% of patients). Phonetic change occurred in three patients within 2 weeks of implant placement.

### Oral Hygiene and Peri-implant Condition

Although patients showed different levels of oral hygiene and maintenance at follow-up, all oral hygiene methods provided satisfactory periodontal maintenance. The water sprayer was preferred by most patients.

## Discussion

Immediate restoration is a reliable modality with high acceptance for completely (or potentially completely) edentulous Chinese patients.

The overall implant survival rate of the All-on-Four treatment concept was 96.2%. This is in accordance with the outcome reported by Malo et al.<sup>3</sup> The present study showed that the tilted implants did not negatively affect the outcome of either implant failures or marginal bone resorption. The extent and pattern of marginal bone resorption for upright implants and tilted implants were similar. This is in accordance with observation by other authors.<sup>8,11</sup>

Postextractive sites with sharp bony edges or prominences on the alveoli should be surgically corrected to create a flat plane.<sup>3</sup> Thus, patients with long-term periodontitis and few untreatable teeth should be surgically corrected to provide a flat plane without any sockets. Alternatively, the patient may require implants to be placed between sockets. It was therefore difficult to evaluate marginal bone changes surrounding implants placed in fresh extraction sockets, and differences from healed sites were not analyzed.

The immediate loading procedure improved patient acceptance of implant treatment. This may significantly reduce treatment time and overall cost. In particular, it may avoid months of complete edentulism or the wearing of an uncomfortable removable denture, which is not favored by most patients with terminal dentition in China. Patient satisfaction with the All-on-Four treatment concept was very high (rated as excellent by 95.6% of patients).

Another factor supporting Chinese patients' acceptance of this approach may be the following: by tilting the posterior implants, sinus elevation procedures are avoided and the morbidity of the surgical phase is reduced. Furthermore, the use of four implants to support the full-arch prosthesis and application of immediate loading protocol can reduce overall treatment costs. These advantages are clinically and socially important for patients with limited dental care, treatment options, and insurance coverage.

Immediate function following the All-on-Four treatment concept is a practical approach for Chinese patients.

According to the third National Oral Epidemiologic Survey of China in 2005, the periodontal health rate of Chinese people aged 65 to 74 years is only 14.1%, with 86.1% exhibiting missing teeth, and the prosthetic treatment rate is only 42.6%.<sup>12</sup> Most Chinese edentulous patients present with severe alveolar bone atrophy due to long-term severe periodontitis. Furthermore, 80% of the Chinese population must pay treatment costs out-of-pocket. Augmentations, such as sinus grafting, increase cost and number of visits. This is unfavorable to Chinese patients for whom it is difficult to frequently visit a clinician. China is a country with vast territory and a large population,

but most well-equipped hospitals and dental offices with well-trained clinicians are located primarily in large cities. In this study, 42 patients (60.9%) came to Beijing from other provinces (mean distance: 691 km). Rural patients have difficulty visiting clinicians located in central cities to receive conventional implant treatment impacting their quality of life. Chinese clinicians are frequently faced with partially edentulous patients who require extraction of hopeless teeth and prosthesis placement as soon as possible. The All-on-Four treatment concept is suited to the needs of Chinese edentulous patients.

### ***Surgical Guide***

Previous authors have reported good outcomes when using four or six immediately loaded implants following the Nobel Guide protocol in European patients.<sup>13</sup> The use of a surgical guide (Nobel Guide) was explored in two completely edentulous patients (one maxilla, one mandible). The limitations of guided surgery in this study included higher pretreatment costs, limited preparation time, and mouth opening of Chinese patients.

The pretreatment procedure included three-dimensional computed tomography, complete denture application, and double scanning. During the surgery, the handpiece with extra-long drill could not be positioned in the posterior opening of the surgical guide template for tilted implants due to limited mouth opening. The distance from the top of the angulated handpiece to the long drill tip was 45 mm, and the fixed surgical guide plate in edentulous alveoli occupied approximately 10 mm of vertical space; thus, at least 55 mm of space was necessary for implant placement with the surgical guide (considering that the missing teeth and alveoli were approximately 57 mm). The mean mouth opening between the maxillary and mandibular central incisor in Chinese patients is 37 mm,<sup>14</sup> and the mean crown length of central incisors is approximately 11.5 mm in the maxilla and 9.0 mm in the mandible.<sup>15</sup> It may only be possible to perform surgical guide operation in the anterior region of arches of most Chinese edentulous patients. Also, most of these patients were unable to come to the clinic for tooth extraction and treatment planning in advance of implant surgery according to protocol. High pretreatment costs and preparation time also limited the number of Chinese patients receiving implant guide therapy.

### ***More Angulated Abutments are Needed***

According to standard All-on-Four protocol, two axially anterior implants were placed in the anterior

maxilla parallel to the midline. The straight multiunit abutments were connected to the upright implants while 17- or 30-degree multiunit abutments were connected to the tilted implants. It was impossible to achieve a common insertion path by using straight abutments in the anterior region for upright implants in most of our Chinese patients. To get the common path of insertion of prostheses, 59 of 76 (77.6%) upright implants in the maxillary anterior region had to be connected with 17- or 30-degree angulated abutments, depending on the clinical situation. This may reflect the maxillary anatomy in Chinese patients. During implant surgery, to avoid implant apical penetration from buccal bone plate requiring a later bone graft and to provide immediate restoration, surgeons had to place both anterior implants following the maxilla axially. This is not upright to the occlusion plane and resulted in angulated implant axes of the so-called upright implants in the front area in the anterior-posterior dimension. Therefore, two 30-degree angulated abutments on the tilted implant posterior area only were not enough to compensate for the discrepancy of the two upright anterior implants, and another two angulated abutments on both anterior implants had to be used to achieve a common insertion pathway. Then, the full-arch prosthesis could be delivered as planned according to the All-on-Four treatment concept.

To the authors' knowledge, no published clinical study discussed the type of multiunit abutments and special selection for anterior upright implants. Three abutment screws loosened, but the angulated abutments connected on the maxillary anterior upright implants did not reflect any difference from the posterior area. Based on the preliminary findings in this study, angulated abutments applied in upright implants in the All-on-Four treatment concept did not have a negative effect on the results; conversely, this approach could help surgeons place implants in a better anatomical situation for immediate function.

### ***Complications***

A learning curve inherent for surgeons using a new technique may have been a factor contributing to implant failures. All implant failures occurred 8 to 10 weeks after implant placement because of lack of osseointegration. Posterior tilted implant failure occurred more often than anterior upright implant failure. It is notable that the majority of implant failures and prosthesis complications occurred in the first year. Most provisional prosthesis fractures occurred close to the copings, which are considered a relatively weak region, in accordance with previous observations.<sup>16,17</sup>

No fracture occurred near the cantilever area in this study. Reinforcing the prosthesis with metal wire and compliance with the soft diet could minimize potential failures of the provisional prosthesis. No implants in this study caused different periodontal reactions versus conventional implant restoration approaches.

### Conclusions

The results of the employed protocol's use in a selected population group, observed over a relatively limited time period, underscore its promise, versatility, and reliability. It also suggests the merits of employing the technique as a viable treatment in a country such as China, with its unique demographic and cultural challenges.

Exploratory use of a surgical guide was limited because of mouth opening, and more angulated abutments were needed in maxillary anterior upright implants.

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