

## Original Article

# Comparison of peri-implant bone resorption around tilted and straight implants in edentulous maxilla with All-on-4 rehabilitation

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## Abstract

**Objective:** Implant supported fixed full-arch prostheses for the severe atrophy edentulous patients is often regarded as a challenge. "All-on-4" concept suggest placing two straight implants in the anterior region combined two tilting implants in the posterior area to overcome anatomical limitations. The purpose of this study was to compare the different peri-implant marginal bone loss between tilted and straight implants of all-on-4 implant-supported fixed prostheses for long-term follow-up.

**Material and Methods:** Patients enrolled in this retrospective study had receive all-on-4 rehabilitations in the Chang Gung Memorial Hospital during February 2016 to February 2020. The peri-implant bone level of tilting and straight implant apart in 0, 3, 12 months after surgery were measured from the panoramic images by using the ruler of a software program. To compensate the radiographic distortion, the marginal bone level measured from panoramic image was divided by the multi-unit abutment height, and used with the real multi-unit abutment height to calculated the corrected marginal bone level. Different peri-implant bone resorption between straight and tilting implants of 3 and 12 months were analyzed with Wilcoxon sign rank test. The initial peri-implant bone level estimated once the implant placement (0 month) was defined as comparison. The statistical significance was defined as  $p < 0.05$ .

**Results:** This study included 10 patients, 5 male and 5 female, the average age was 51.4 years (range from 36 to 68 years). Total of 40 implants in maxilla were placed, included 20 straight and 20 tilted implants. Wicoxon sign rank test showed Z score - .336 at 3 months follow-up and -.485 in the 12 months follow-up.  $P = .737$  and  $P = .627$  for the 3 months and 12 months respectively.

**Conclusions:** No significant difference was shown in the peri-implant bone resorption between straight and tilting implants of all-on-4 implant rehabilitation for both 3 months and 12 months follow-up time. All-on-4 implant-supported fixed prosthesis was considered as a reliable solution for severe atrophy edentulous ridge.

**Key words:** All-on-4 rehabilitation, Peri-implant bone level, Tilting implant, Straight implant

## Introduction

The edentulous condition or terminal un-restorable dentition shows poor chewing function and poor esthetics, as well negative impacts on oral health related quality of life. It can be derived from many factors such as extensive dental caries, severe periodontal disease, trauma or tumor. Immediate rehabilitation with implant supported fixed full-arch prostheses for the edentulous patients has been associated with a high level of satisfaction about esthetics, phonetics and functionality<sup>1,2</sup>. However, rehabilitation of severe atrophy maxilla with fixed prosthesis is often complicated due to anatomical limitations, such as maxillary sinus, poor quality and quantity of bone. Bone grafting or other augmentation procedures are used to increase the bone volume for implant placement, though complications occurs, such as increase surgical difficulties and prolong the treatment time. Malo<sup>3</sup> et al used the tilted implants as an alternative approach to treat atrophy edentulous patients and named it the "all-on-4" concept. As suggested, placing two straight implants in the anterior region and two implants, tilted 30 ° to 45 ° relative to the occlusal plane, in the posterior area<sup>3,4,5,6</sup>. Tilting the posterior implants preserves anatomical structures and reduces the need for bone augmentation, which results in reducing surgical invasion, shorter treatment time and lower costs. Tilting allows the placement of longer implants with good cortical anchorage in optimal positions for prosthetic support, it increases the contact area between the implant and the bone, thus enhances the implant primary stability<sup>7</sup>. Tilting the implants in the posterior regions can also reduce the length of cantilever. Previous study showed implants with distal cantilever longer than 15mm lead to higher risk of failure<sup>8</sup>. Tilting increases the distance between anterior and posterior implants, the implant support is more distal, thus the cantilever length was reduced or even eliminated. It provides the better stress distribution and the proper anterior-to-posterior spread of the implants.

In vitro studies showed that unfavorable loading direction may accentuate stresses around implant neck which non axially were placed, as it could cause more marginal bone loss around the implants<sup>9,10</sup>. In all-on-4 concept treatment, the tilted implants and the straight implants are splinted, we supposed that may re-distribute the occlusal forces. The purpose of this study was to

compare the different peri-implant marginal bone loss around tilted and straight implants of all-on-4 implant-supported fixed prostheses for long term follow-up.

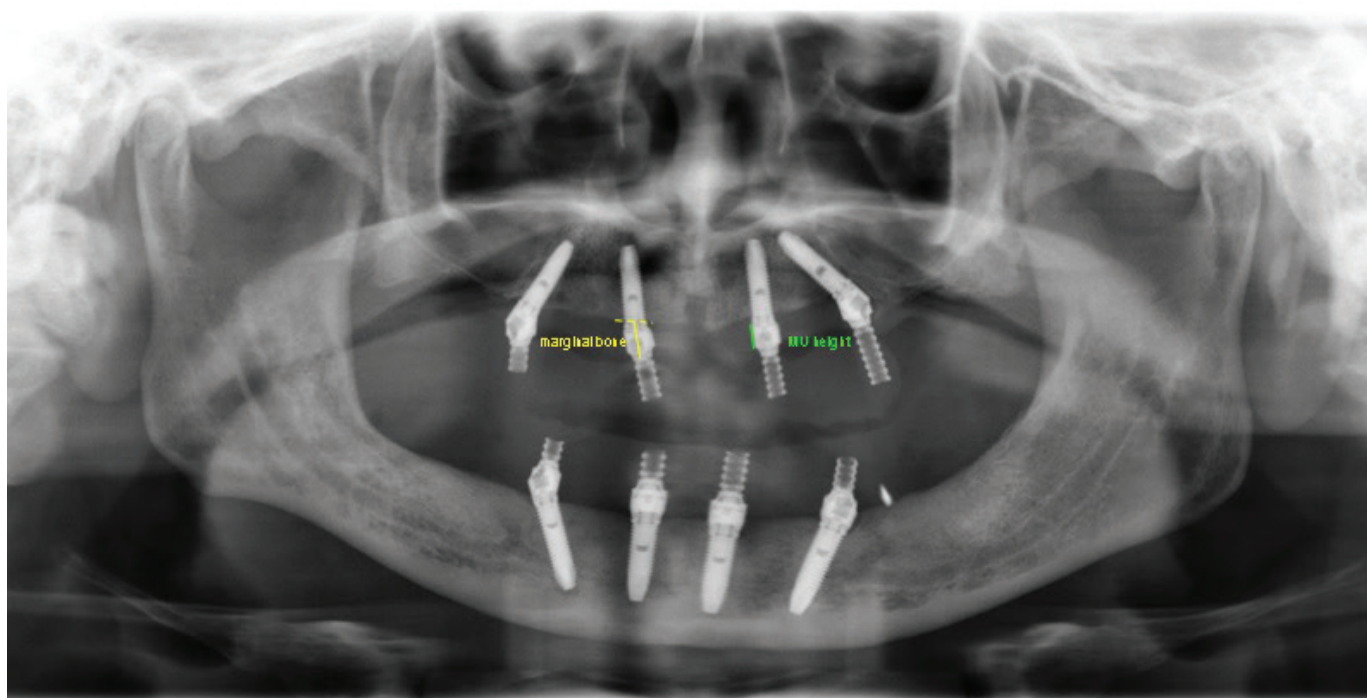
## Materials and methods

Those patients receive all-on-4 rehabilitations in the Chang Gung Memorial Hospital from February 2016 to February 2020 were enrolled in this study. Participants are those who had edentulous or remaining hopeless teeth which planned for extraction, mainly moderate or severe atrophy of the maxillary that bone augmentation was necessary for placing implants in the posterior region. They all received preoperative clinical and radiographic evaluation, panoramic and cone-beam computerized tomography. These subjects were restricted to have good health, no neuromuscular disorder, head and neck cancer history, and nor temporomandibular joint disorders. All participants had proceed all-on-4 implant rehabilitation as inform consent undersigned.

Surgical procedure placed 2 straight implants in the premaxilla area and 2 tilted implants (30 to 45 degree) in the posterior region. The multi-unit abutments were connected to implants during surgical procedure, and an all-acrylic resin with all-on-4 design fixed provisional prostheses were delivered for early loading within 2 weeks after surgery. Surgeon recorded all the implant fixture size and the multi-unit abutment size in the patients. Definitive prosthesis was delivered 6-8 months later until soft and hard tissue heals completely. The prosthesis was designed as hybrid denture and fabricated with the CAD/CAM IBO titanium framework combined with acrylic resin teeth, each denture contained 12 resin teeth from incisor to first molar every quarter.

All participants were closely followed-up every week within the first 2 months, as well each month during 3-12 months period. Panoramic radiograph was taken on the day of surgery as baseline and every month after surgery for regular evaluation. The peri-implant bone level of tilting and straight implant measured in 0, 3, 12 months after surgery were recorded.

The marginal bone level and multi-unit abutment height were measured from the panoramic images by using the ruler of a software program (Dental PACS, version 2.3; GE Healthcare Inc). The marginal bone level was calculated from the first bone to implant contact interface to the tip of the multi-unit abutment. (Fig.1) To compensate



**Figure 1.** The marginal bone level and MU height were measured from the panoramic image. To compensate for the image distortion of the panoramic radiograph, the marginal bone level was divided by the MU abutment height as a ratio, and the ratio was used with the real MU abutment height to calculated the real marginal bone level. (MU: multi-unit abutment)

for the image distortion of the panoramic radiograph, the marginal bone level was divided by the multi-unit abutment height as a ratio, and the ratio was used along with the real multi-unit abutment height to calculated the real marginal bone level. The altered marginal bone level from 0 to 3 months and 0 to 12 months were defined as peri-implant bone loss. The marginal bone level measured before prosthodontic rehabilitation (0 month) were regarded as comparison.

Different peri-implant bone resorption between straight and tilting implants in every follow-up period as 3 and 12 months were analyzed with Wilcoxon sign rank test. The statistical significance was defined as  $p < 0.05$ . A statistical software program (IBM SPSS Statistics version 20) was used for the analysis.

## Results

10 patients were selected for this study, 5 male

and 5 female, the average age at surgery was 51.4 years (range from 36 to 68 years). Total of 40 implants in maxilla were placed, included 20 straight and 20 tilted implants. At the 3-month follow-up, the mean marginal bone loss of the straight implants was  $1.40 \pm 2.21$  mm (maximum = 8.49 mm and minimum = -2.09 mm), compared with  $1.04 \pm 0.98$  mm for the tilted implants (maximum = 2.67 mm and minimum = -1.62 mm). At the 12-month evaluation, average was  $0.97 \pm 2.63$  mm (maximum = 8.26 mm and minimum = -3.74 mm) for straight implants and  $1.24 \pm 2.45$  mm (maximum = 4.58 mm and minimum = -3.41 mm) for tilted implants (Table 1).

As the analyses of Wilcoxon sign rank test shown in Table 2, Z score was - .336 at 3 months follow-up and - .485 at 12 months follow-up.  $P = .737$  and  $P = .627$  at 3 months and 12 months respectively. No significant difference in marginal bone loss between straight and tilted implants was detected.

**Table 1.** The peri-implant bone level of straight and tilting implants estimated in 3month and 12 month after implant surgery compared to 0 month.

| Implant an-gulation | Time      | Mean | Max  | Min   | SD   |
|---------------------|-----------|------|------|-------|------|
| Straight            | 3 months  | 1.40 | 8.49 | -2.09 | 2.21 |
|                     | 12 months | 0.97 | 8.26 | -3.74 | 2.63 |
| Tilting             | 3 months  | 1.04 | 2.67 | -1.62 | 0.98 |
|                     | 12 months | 1.24 | 4.58 | -3.41 | 2.45 |

**Table 2. Wilcoxon sign rank test(P<0.05). <sup>a</sup>tilting<straight, <sup>b</sup>tilting>straight, <sup>c</sup>tilting=straight**

|                           | n   | Mean rank | Sum of ranks | Z score | P    |
|---------------------------|-----|-----------|--------------|---------|------|
| 3 month Straight-tilting  |     |           |              |         |      |
| Negative ranks            | 10a | 11.40     | 114.0        | -.336b  | .737 |
| Positive ranks            | 10b | 9.60      | 96.00        |         |      |
| Ties                      | 0c  |           |              |         |      |
| Total                     | 20  |           |              |         |      |
| 12 month Straight-tilting |     |           |              |         |      |
| Negative ranks            | 9a  | 10.22     | 92.00        | -.485b  | .627 |
| Positive ranks            | 11b | 10.73     | 118.00       |         |      |
| Ties                      | 0c  |           |              |         |      |
| Total                     | 20  |           |              |         |      |

## Discussion

This study demonstrates no significant differences in peri-implant bone resorption between straight and tilted implants of all-on-4 implant rehabilitation for a long term follow-up. The result was coincidental to the previous studies that all-on-4 concept can be regarded as a feasible treatment for severe atrophy edentulous ridge<sup>11,12</sup>.

Previous studies indicated high survival rates for tilted implants<sup>13</sup>. It can be used to reduce cantilever length and give better load distribution on the prosthesis. Past investigation revealed the load concentrate around cervical region of the single tilting implant<sup>14</sup>. During chewing function, the vertical loading is supposed to cause more bone destruction around the tilted implant, the stress concentrated in the marginal area of bone might increase the bone resorption<sup>15</sup>. However, when implants are used in a full-arch fixed prosthesis, the tilted implants and the straight implants are splinted to each other and behavior as a functional unit, not as isolated elements, it might limit implant micro-motion and change the distribution of the loading forces, which may results in reduce stress on the peri-implant bone<sup>16,17</sup>. This is the preliminary study to investigate the different bone resorption of tilting and straight implants in Taiwan, and results were coincidental to multiple previous researches which shows no significant difference of the bone resorption between straight and titling implants<sup>17,18,19</sup>. Hence, the all-on-4 implant rehabilitation is a reliable treatment modality for those who has severe bone defect. Some previous study suggested the definitive prostheses delivered after 3 months of healing time for all-on-4 treatment protocol<sup>20,21</sup>, thus many studies follow up the implants up to 12 months as long-

term survey. Therefore, this study analyzed the peri-implant bone resorption on 3 months and 12 months after implant placement.

Although the main bone resorption regularly occurs in the first year after implant surgery, long-term follow-up may effectively represent functional loading. Besides, the different angulation degree of the tilted implant and distal cantilever length may influence the marginal bone loss in those who receives all-on-4 treatment. The angulation of distal implants is usually tilted 30 ° to 45 ° and the cantilever length was limited within 15mm, but these up-limitation variables had never been measured in the present study, such interesting issue is worthy of further discuss.

All radiographic methods have been utilized the marginal bone estimation. Although bitewing examination is the first choice of image modality to assess the marginal bone level at premolar region due to excellent reliability, it appeared to be none suitable for estimating the tilting implant of all-on-4 implant system. The past investigation indicated the inter-observer agreement in marginal bone assessment from intraoral and panoramic radiographs and found the same agreement rate methods<sup>22</sup>. The previous study compared the intraoral and panoramic radiography to evaluate the peri-implant marginal bone level and considered the panoramic radiographs were as reliable as the intraoral radiographs, though the calculation methods should be carefully selected<sup>23</sup>. As for the possible existence of panoramic radiograph, a rough estimation of marginal bone level at premolar region is clinically acceptable bearing in mind that bone height of the mandible premolar region might be overestimated as compared to bitewing radiograph<sup>24</sup>. Based on previous study

proposed that variables measured from the panoramic radiographs may have been affected by distortion<sup>25</sup>, this study utilized the calculation of the MU height to compensate the radiographic distortion for realism increased.

By placing longer implant, posterior tilted implants enlarges the contact area between bone and implants, it could enhance osteointegration and provide better loading distribution. And we supposed the occlusal loading could re-distribute by means of splinting the straight and tilted implants. All maybe the reasons that the peri-implant bone resorption around tilted implants were deceased. Future analysis maybe proceed on the relationship between the length of tilted implant fixture and bone resorption.

## Conclusion

All-on-4 implant-supported fixed prosthesis was regarded as a reliable solution for severe atrophy edentulous ridge. No significant difference was observed between straight and tilted implants in peri-implant marginal bone loss.

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## Conflicts of interest

None.

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