

Original article

Evaluation of the therapeutic efficiency of mandibular anterior implant-supported fixed bridges with cantilevers

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Keywords: *implant; cantilever; fixed bridge; mandibular; bone resorption*

Background Dental implant technology has developed rapidly in recent years. However, the use of implant-supported fixed bridges with cantilevers has been controversial. The purpose of this study was to evaluate the clinical results of the mandibular anterior implant-supported fixed bridges with a cantilever.

Method Thirty-three patients (15 males, 18 females; mean age, 42.6 years; range 20–54 years) with two missing anterior mandibular teeth had single implant-supported fixed bridges with a cantilever. Clinical examination was recorded and radiographs were taken. The mean duration of follow-up was 30 months (15–44 months).

Results All implants survived. Loosening or fracture of the prosthesis was not observed. All patients were satisfied with the treatment. The mean bone resorption values after 12, 24, and 36 months of implant loading were 0.94, 1.18 and 1.35 mm respectively. The changes of gingival papilla height ranged from 0 to 0.5 mm. There was significant difference between 1-year and 2 or 3 years restoration groups regarding the average gingival height changes ($P < 0.05$).

Conclusion After careful and precise selection of patients, restoration with a single implant-supported fixed bridge with a cantilever can be recommended if two anterior mandibular teeth are missing.

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Dental implant technology has developed rapidly in recent years. However, the use of implant-supported fixed bridges with cantilevers has been controversial. The use of implant-supported fixed bridges with cantilevers in the anterior region can solve the problem of insufficient inter-implant and tooth-implant distances, preserve interdental papilla and soft tissue architecture, and achieve good aesthetic standards. A common approach in anterior regions is the insertion of implants in incisor or canine positions with the other incisors, the lateral incisors or as cantilevers. This study aimed to evaluate the clinical outcome of anterior implant-supported fixed bridges with cantilevers. We focused on the effect of treatment on the preservation of bone tissue, and anticipated to provide information guidance on the surgical procedure for reference.

METHODS

Clinical data

Thirty-three patients (15 males and 18 females with age of 20–54 years) whose two anterior mandibular teeth were missing formed the study cohort. They had agreed to undergo implant-supported fixed bridges with a cantilever from October 2008 to March 2011 at the Second Dental Center, Peking University School and Hospital of Stomatology (Beijing, China). Inclusion criterion for the study was patients with a history of two mandible anterior tooth loss and receiving subsequent implant restoration. The edentulous space was enough for implantation treatment. The adjacent teeth and opposite teeth were recorded no endodontic and periodontal problems. Exclusion criterion was the adjacent teeth with either severe periodontal disease

or tooth mobility ranked 2 degree or above. Smoking more than 20 cigarettes per day would be excluded from this study. Nocturnal bruxism, diurnal clenching, gingival index above, poor oral maintenance even after oral health instruction, and poor compliance would all be excluded from the study. Thirty-three implants (19 Straumann implants and 14 NobelReplace® implants) were placed in the mandibles of these patients. The shortest length of the implant was 10 mm and the maximum was 14 mm. A total of 33 porcelain fused to noble metal cantilever fixed bridges was manufactured (only with a cantilever, the mesiodistal diameter of the cantilever does not exceed the retainer). The fixed bridges would be attached later to the implant by cementation. From the time the bridge was cemented to the final follow-up visit, the longest duration was 44 months and the shortest was 15 months (mean 30 months).

Procedures

Routine oral examinations, radiography examinations (panoramic and periapical views) and CT imaging were employed to ascertain the quality of the edentulous space of the mandible and to determine the optimal position of implant insertion. All the implantation treatments were done

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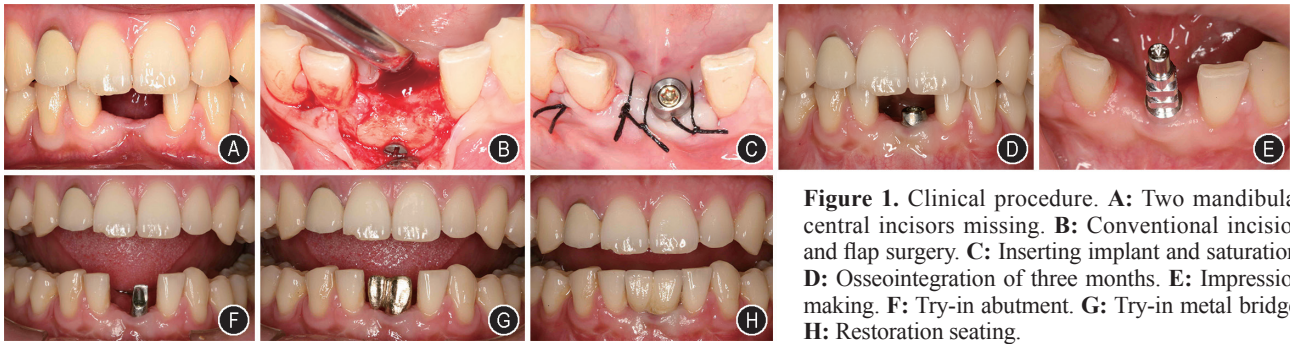


Figure 1. Clinical procedure. **A:** Two mandibular central incisors missing. **B:** Conventional incision and flap surgery. **C:** Inserting implant and saturation. **D:** Osseointegration of three months. **E:** Impression making. **F:** Try-in abutment. **G:** Try-in metal bridge. **H:** Restoration seating.

after signing consent files and initial periodontal treatments were received by the patients. Flapless dental implant surgery was performed and the implants were inserted in the lingual side of the ridge to ensure the center of the implant was in the position of future crown's lingual protuberance. At 3–4 months after implant surgery, the super-structure of the mandible was repaired. A “window type” impression was taken at the implant level using a transfer pin and then the plaster cast was irrigated. The manufactured porcelain was fused to cantilever fixed bridges made of noble metal (gold: 86.2%, platinum: 11.5%, Heraeus, Berlin, Germany). Figure 1 shows the procedure.

Observation

Survival rate

The survival rate means the implant is still physically and functionally in the mouth after the permanent restoration. Survival rate = (successful implants/total implants) 100%.

Evaluation of patient's satisfaction

A questionnaire was given to the patients to evaluate their level of satisfaction with the dental prosthesis, which was scored from 0 to 10 (complete dissatisfaction to complete satisfaction).

Clinical examination

The indices of clinical examination were whether the prosthesis was intact; the porcelain was broken; the prosthesis coordinated with the color of the adjacent teeth; the prosthesis was loose, likely to fall off, occlude other teeth, or had a poor fit. A score of “A” denoted a good fit and “B” denoted a bad fit (Table 1).

Evaluation of soft tissue esthetic

The change of gingival papilla height (the distance between the peak of gingival papilla and mesial-distal incisal angle)

Table 1. Scoring system used for the implants

| Parameter | Grade | Notes |
|----------------------|--------|---|
| Retention | Good A | Not loose |
| | Bad B | Loose or dislodged |
| Fracture or breakage | Good A | No fracture and no breakage |
| | Bad B | Fracture or breakage; recording the location and form |
| Color | Good A | Color coordinates with adjacent teeth |
| | Bad B | Color does not coordinate with adjacent teeth |
| Margin fitness | Good A | Margin without visible slit and probe is smooth |
| | Bad B | Margin with visible slit and probe is not smooth |
| Occlusal function | Good A | Good function, good contour and occlusal relationship |
| | Bad B | Bad function, bad contour and occlusal relationship |

was selected to evaluate the esthetic of soft tissue. The chosen time points were immediately after the restoration and 30 months later. The chosen sites were the peak of gingival papilla between implant and implant-adjacent tooth (ITP), between pontic and pontic-adjacent tooth (PTP), and between implant and pontic (IPP). It means that gingival papilla height increased when the numerical calculation was in negative. It represented gingival recession when the data was in positive. All the measurement was performed by a periodontal specialist.

X-ray examination

Radiographs were taken to quantify the alterations in marginal bone. The mean changes in the height of the mesial and distal bones of each implant were measured to quantify peri-implant bone resorption. Using periapical films, the digital parallel projection was entered into ODIS image analysis software. This enabled us to ascertain the length of the implant or thread pitch in the radiograph, as well as the distance from the level of the mesiodistal crestal bone to the bottom of the implant (Figure 2). Positive values indicated a reduced bone height, whereas negative values indicated an increase in bone height. Three measurements were taken by the same surgeon and an average value was calculated.

Statistical analysis

Data were expressed as mean ± standard deviation (SD)

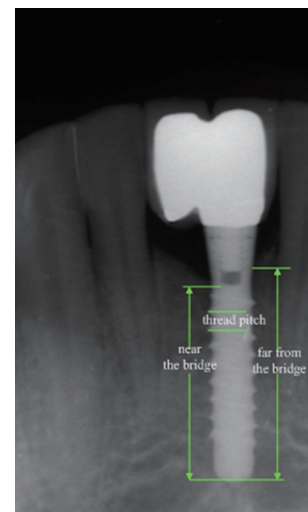


Figure 2. The peri-implant bone height measurement

and analyzed using SPSS19.0 software (SPSS Inc., USA). The intergroup comparison was performed using *t*-test; and the count data were passed through non-parametric test, *P* <0.05 considered as statistically significant.

RESULTS

Implant survival rate

Thirty-three prostheses (19 Straumann implants and 14 NobelReplace® implants) were implanted in the mandibles of 33 patients. The shortest length of the implant was 10 mm and the maximum was 14 mm. A total of 33 porcelain fused to noble metal cantilever fixed bridges was manufactured (only with a cantilever, the mesiodistal diameter of the cantilever does not exceed the retainer). No obvious abnormal implants were noted from the loading to the final follow-up. All implants survived. Four months after loading, one patient noted loosening of the central screw. Removal of the upper single-ended bridge and replacing the central screw helped to re-fix the bridge. After 18 months, rechecking of the alterations demonstrated good restoration. With respect to follow-up, six cases were reviewed >1 year after the loading, 16 cases >2 years, and 11 cases >3 years. Thirty-three implants placed in 33 patients during the final follow-up were not obviously abnormal. Implant survival rate is 100%.

Patient satisfaction

With regard to patient satisfaction of the restorative effects, eight cases scored 10 points; 15 cases scored 9 points; eight cases scored 8 points; and two cases scored 7 points. The mean score for satisfaction was 8.9 points. Gingival recession was observed in three patients, but had little influence on cosmetic appearance because the lower lip was covered.

Clinical evaluation

The results of clinical examinations of all 33 cases 1, 2, and 3 years after repair were good. And all implant-supported single-ended bridges were deemed not loose, broken, or fractured; the implants fitted well (margin was small); the color coordinated with the adjacent teeth; and occlusion function was good (Table 2).

Changes of gingival papilla height

The changes of gingival papilla height 1, 2, and 3 years after loading were shown in Table 3.

The average of gingival papilla height recorded a decreasing trend after restoration in all the 33 cases with

Table 2. Clinical evaluation of the 33 implants

| Time after loading | Years | | | | | | | | | Total | | |
|----------------------|-------|---|-------|----|---|-------|----|---|-------|-------|---|-------|
| | 1 | | | 2 | | | 3 | | | A | B | Total |
| | A | B | Total | A | B | Total | A | B | Total | | | |
| Retention | 6 | 0 | 6 | 16 | 0 | 16 | 11 | 0 | 11 | 33 | 0 | 33 |
| Fracture or breakage | 6 | 0 | 6 | 16 | 0 | 16 | 11 | 0 | 11 | 33 | 0 | 33 |
| Color | 6 | 0 | 6 | 16 | 0 | 16 | 11 | 0 | 11 | 33 | 0 | 33 |
| Margin fitness | 6 | 0 | 6 | 16 | 0 | 16 | 11 | 0 | 11 | 33 | 0 | 33 |
| Occlusal function | 6 | 0 | 6 | 16 | 0 | 16 | 11 | 0 | 11 | 33 | 0 | 33 |

implant-supported fixed bridges with cantilevers. The changes of gingival papilla height ranged from 0 to 0.5 mm. There was significant difference between 1-year and 2 or 3 years restoration groups, regarding the average gingival height changes (*P* <0.05). There was no significant difference between 2 and 3-years restoration group (*P* >0.05). The change of gingival papilla height in IPP was higher than ITP and PTP at different loading time point. There is no significant difference between ITP and PTP (*P* >0.05).

Health condition of peri-implant soft tissue

In this study, most sites of the 33 implants surface (132 sites in total) had varying degrees of plaque accumulation (Table 4). The percentage of sites which PLI was 3 was increasing with the implant loading time lasting. Difference was statistically significant (*P* <0.05).

The outcome of probing depth measurement at implant sites is shown in Table 5. The mean probing depth of implant sites was (2.5±1.3) mm. The probing depth (PD) of 35 sites (26.5%) was either equal to or greater than 4.0 mm. There was no significant difference between the PD measurement at different time after loading.

Sulcus bleeding index (SBI) was used to evaluate the intensity of gingival inflammation. Health sites occupied 20.5% in all the probing sites (27/132). The sites of mild inflammatory were 40.1% (53/132), the middle was 32.6 (43/132), and the severe was 6.8% (9/132). The detail of inflammatory condition at different time point could be seen in Table 6 and there was no significant difference among different groups (*P* >0.05). The mild inflammatory sites (SBI=1) accounted the majority, followed by the middle inflammatory group (SBI=2).

Changes of peri-implant bone level

Changes in peri-implant bone level could not be analyzed due to poor image quality of the radiographs and missing

Table 3. Changes of gingival papilla height after loading

| Time after loading | 1 year | 2 years | 3 years | Total |
|--------------------|-----------|-----------|-----------|-----------|
| Cases (n) | 6 | 16 | 11 | 33 |
| IPP (mm) | 0.17±0.49 | 0.21±0.52 | 0.22±0.41 | 0.21±0.48 |
| ITP (mm) | 0.15±0.58 | 0.16±0.69 | 0.18±0.47 | 0.17±0.61 |
| PTP (mm) | 0.13±0.65 | 0.15±0.46 | 0.16±0.52 | 0.15±0.58 |
| Total (mm) | 0.15±0.56 | 0.19±0.45 | 0.20±0.50 | - |

Table 4. Outcomes of PLI measurement peri-implant after loading (n (%))

| PLI | 1 year | 2 years | 3 years | Total |
|-----|----------|-----------|-----------|-----------|
| 0 | 6 (25.0) | 10 (15.6) | 8 (18.2) | 24 (18.2) |
| 1 | 5 (20.8) | 9 (14.1) | 7 (15.9) | 21 (15.9) |
| 2 | 6 (25.0) | 16 (25.0) | 6 (13.6) | 28 (21.2) |
| 3 | 7 (29.2) | 29 (45.3) | 23 (52.3) | 59 (44.7) |

Table 5. Outcomes of probing depth measurement peri-implant after loading

| parameters | Time after loading | | | Total |
|-----------------------------|--------------------|-----------|-----------|-----------|
| | 1 | 2 | 3 | |
| PD (mm) | 2.7±1.8 | 2.5±1.5 | 2.4±1.6 | 2.5±1.3 |
| sites ((PD ≥4.0 mm, n (%))) | 5 (20.8) | 19 (29.7) | 11 (25.0) | 35 (26.5) |

Table 6. Outcome of SBI measurement peri-implant after loading (n (%))

| SBI | Year | | | Total |
|-----|----------|-----------|-----------|-----------|
| | 1 | 2 | 3 | |
| 0 | 7 (29.2) | 14 (21.9) | 6 (13.6) | 27 (20.5) |
| 1 | 9 (37.5) | 25 (39.1) | 19 (43.2) | 53 (40.1) |
| 2 | 7 (29.2) | 20 (31.3) | 16 (36.4) | 43 (32.6) |
| 3 | 1 (4.2) | 5 (7.8) | 3 (6.8) | 9 (6.8) |

Table 7. The changes of the mesial and distal peri-implant bone levels after loading

| Time after loading | 1 year | 2 years | 3 years |
|--------------------------|-----------|-----------|-----------|
| Cases | 6 | 16 | 9 |
| Near the bridge (mm) | 1.00±0.30 | 1.25±0.53 | 1.46±0.53 |
| Far from the bridge (mm) | 0.88±0.23 | 1.11±0.40 | 1.23±0.48 |
| Mean of both sides (mm) | 0.94±0.24 | 1.18±0.45 | 1.35±0.43 |

radiographs in two cases. However, complete imaging data was obtained for the other 31 patients (Table 7). The mean values for bone resorption 1, 2, and 3 years after loading were (0.94±0.24) mm in six cases, (1.18±0.45) mm in 16 cases, and (1.35±0.43) mm in nine cases, respectively. The differences of changes of the mesial and distal peri-implant bone levels were not significant ($P > 0.05$).

DISCUSSION

Several clinical and experimental studies have shown that osseointegration of implanted dentures is an effective long-term method to repair partially edentulous arches and edentulous jaws. For implant-supported restoration with a cantilever, the prevalence of survival of implants is only slightly lower than that for rigidly fixed bridges. Implant-supported fixed bridges with a cantilever can result in good long-term clinical effects.¹⁻⁶ Studies have shown that compared to conventional fixed bridges, implant-supported fixed bridges with a cantilever have a low prevalence of success and are associated with more complications after repair.^{2,7,8} The long-term effects of implant-supported fixed bridges with a cantilever merit further study.⁹⁻¹¹ When reviewing >1 year after implantation, the survival rate for the 33 mandible anterior implant-supported fixed bridges with a cantilever was 100%. Three years after implantation, the prevalence of survival remained 100%. Clinical examinations showed: no obvious mechanical complications, good retention, good fit of the margin, good recovery of occlusal function, no collapse or fracture of porcelain, good color coordination with adjacent teeth, and good subjective assessment of repair. The recession of gingival height was less than 1 mm around the prosthesis and this did not much harm the esthetic of mandible anterior teeth. The present study suggests that implant-supported fixed bridges with a cantilever could be used if two mandible anterior teeth are missing and that the clinical effects are good. Our study also showed that the condition of peri-implant soft tissue was unsatisfactory. Only 20.5% sites were healthy without bleeding on probe. The plaque index was 3 in 44.7% sites (59/132); 40.1% (53/132) sites were mild inflammatory. A measured percentage of 39.4% (52/132) sites were middle and severe gingival inflammatory. However, normal peri-implant gingival status

was only observed in 48.5% of the subjects, especially the lingual gingival condition. Hence, after the repair, peri-implant gingival health conditions were not ideal in more than half of the patients.

The stability of the bone around the implant is the key to success. The amount of resorption is an important indicator to assess implant success.¹²⁻¹⁴ Studies have shown that an implant-supported fixed bridge with a cantilever design and the length of the cantilever do not affect the increase in bone resorption around the implant.^{1,15,16} More than one year after fixed bridge with cantilever loading, radiographic examination showed that the mean edge bone resorption in 33 implants was about 1.5 mm with the time increasing. In terms of two-stage implants, the amount of bone resorption was within an acceptable range.^{12,18} We also found that the differences in the peri-implant changes in the height of the mesial and distal bones were not significant. Aglietta et al's¹⁹ study is too hard to reach the same result. This finding suggests that a cantilever design with a bridge width that does not exceed the mesiodistal diameter of the retainer might not lead to increased bone resorption. The results of other studies also supported the reliability of suitably fabricated cantilever prostheses on implant.^{19,20}

The present study has a number of limitations. The sample size was relatively small and the follow-up time was quite short. Nevertheless, the present study provides important information for further studies of this important issue in dental restoration.

After careful and precise selection of patients, restoration with a single implant-supported fixed bridge with a cantilever can be recommended if two anterior mandibular teeth are missing. However, further studies are needed to evaluate the long-term therapeutic efficiency of mandibular anterior implant-supported fixed bridges.

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