# A Comparative Study of One Implant Versus Two Replacing a Single Molar

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A comparative study between one and two Brånemark implants replacing a single molar was conducted. Forty-seven individuals comprised two groups of 22 patients treated with one implant and 25 with two implants. A total of 72 implants were placed, 66 (92%) in the mandible and six (8%) in the maxilla. After the first year of function, the success rate was 99%, with only one implant lost. Between the second- and third-year follow-ups, 100% of the implants continued to function in the remaining 46 patients, giving a 3-year cumulative success rate of 99%. The marginal bone loss between 1 and 3 years of function was 0.10 mm (SD 0.20) for the group with one implant and 0.24 mm (SD 0.20) for the group with two implants. No changes were observed in the Sulcus Bleeding Index during the 3-year follow-up. Prosthesis mobility or screw loosening was the most frequent complication and was predominant in the group using one implant (48%), but was substantially reduced in the group using two implants (8%). These mechanical problems, using one implant only, seem to be preventable using a stronger screw joint (CeraOne abutment). Precise centric occlusal contact was established and maintained over the study period, which was thought to contribute to the very high success rate for the single-implant–supported molars, despite their high degree of mechanical problems. This study suggests that implant-supported molars can be effective therapy, and the results confirm the biomechanical analysis that two implants provide more advantageous support than does one.

(Int J Oral Maxillofac Implants 1996;11:372–378)

**Key words:** biomechanical analysis, comparative study, complications, marginal bone loss, single-molar implant

Implant restorations of single anterior teeth with the Brånemark System (Nobelpharma AB, Göteborg, Sweden) have demonstrated high predictability in a multicenter prospective study[1] with a cumulative success rate of 97% at the 3-year follow-up. However, single-implant replacement of a molar has limited clinical documentation. In the aforementioned study[1], only five of the 107 implants were placed in the molar region. A second clinical study[2] of 40 single-tooth implants loaded from 1.4 to 6.6 years (mean 2.9 years) included only five molar replacements. To the knowledge of the authors of the present study, the only other published material focusing on single molar implants is a retrospective study[3] of 24 implants followed-up for 2 years with a cumulative success rate of 96%.

Replacing a lost molar with only one implant represents a biomechanical challenge. Lateral forces create a bending moment relative to the implant at its marginal bone, and axial forces introduce bending if offset from the implant axis in a mesiodistal or buccolingual direction (Fig 1). In combination with the fact that occlusal forces are at their greatest in the molar region, this leads to possible elevated stress on components as well as bone. Furthermore, the screw joint for a single tooth is susceptible to loosening because a torque relative to the implant axis must be counteracted by the screw joint itself. In multiple implant restorations, the adjacent implant(s) perform this counter action.

Implant-supported molar replacement also means mixing natural teeth and implants in the same quad-

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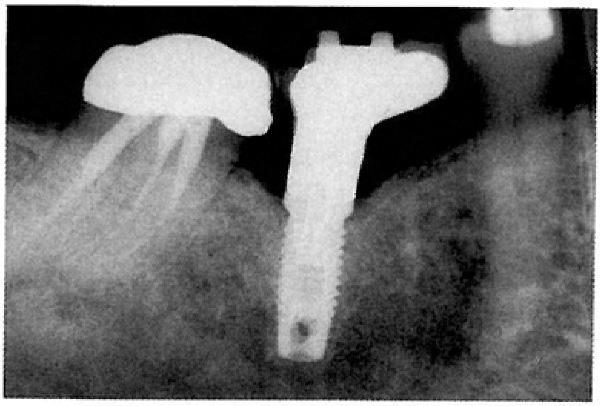

**Fig 4** A single-molar restoration supported by one single implant.

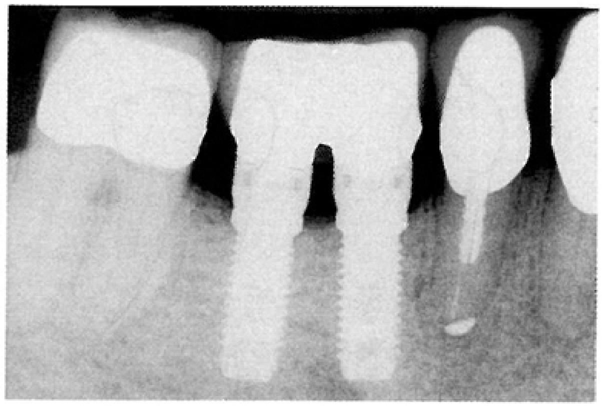

**Fig 5** A single-molar restoration supported by two implants.

**Table 1** Age and Sex Distribution of the Patient Groups

| | | Age (y) | | | | | |
|---|---|---|---|---|---|---|---|
| Group | Sex | < 31 | 31–40 | 41–50 | 51–60 | 61–70 | Total |
| 1 | F | 0 | 2 | 4 | 2 | 4 | 12 |
| | M | 1 | 2 | 1 | 3 | 3 | 10 |
| 2 | F | 2 | 0 | 7 | 5 | 3 | 17 |
| | M | 1 | 2 | 1 | 0 | 1 | 5 |

**Table 2** Bone Quality at Implant Site

| Bone quality | Maxilla | Mandible |
|---|---|---|
| Type 1 | 0 (0%) | 0 ( 0%) |
| Type 2 | 0 (0%) | 6 (12.7%) |
| Type 3 | 3 (6.3%) | 23 (48.9%) |
| Type 4 | 3 (6.3%) | 12 (25.5%) |

been replaced with one and two implant–supported prostheses (Figs 4 and 5, respectively), with all patients followed-up for a period of 3 years.

## Materials and Methods

Forty-seven patients were treated for the replacement of a lost molar with free-standing osseointegrated implants. Twenty-two were treated with one implant (group 1) and 25 with two implants (group 2) (Table 1). The placement of the implants was performed ad modem Brånemark, with the modification that countersinking was eliminated at the surgical stage to provide the most optimal thread engagement in the marginal cortical bone. Bone quality in the edentulous area was evaluated by the same operator at the time of implant surgery (Table 2) using the criteria proposed by Lekholm and Zarb.[6] The healing time before prosthesis loading was 3 to 4 months in the mandible and 5 to 6 months in the maxilla. Seventy-two implants were placed, of which 66 (92%) were in the mandible, and 6 (8%) in the maxilla. The number and distribution of implants according to the position and size is given in Table 3, and the type and size of abutments used is given in Table 4.

The inclusion criterion for patient selection in the study was a lost single-molar tooth that had adjacent natural teeth, as well as a natural tooth antagonist. The exclusion criteria included insufficient bone quality or quantity, insufficient interarch space, oral status not permitting a predictable 3-year stable periodontal and endodontic status of adjacent teeth, and patient drug dependency. None of the patients had systemic diseases or medical histories that contraindicated treatment.

During an inclusion period of 2 years, patients were consecutively selected after accepting the treatment; the choice between one or two implants was based on the size of the interdental space. For patients with a 12-mm or larger space, two implants were used. For patients with less space, one implant was used. The opposing occlusion for all patients in this study was natural dentition, except for one patient in whom the single molar was opposed by an osseointegrated implant–supported restoration. The causes of tooth loss for the 47 patients included were

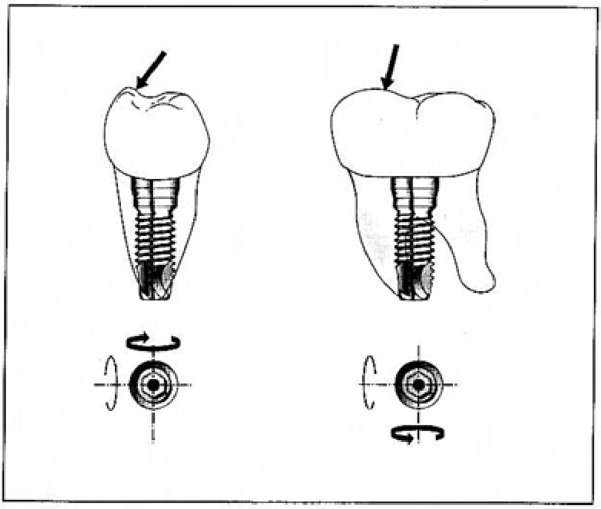

Fig 1 For the single-implant single-molar replacement, the dimensions of the tooth crown are substantially larger than the diameter of the implant, leading to possible bending in all directions.

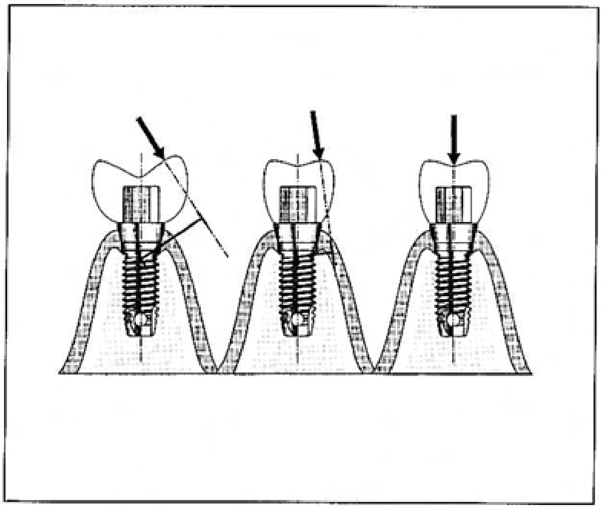

Fig 2 If cuspal contact is allowed, the cusp inclination and position of the lateral excursive contact determine the leverage; the more lateral the contact and the larger the inclination, the greater bending moment.

rant, thus providing both movable and nonmovable segments. Teeth suspended by the periodontal ligament may range in mobility from 50 µm in the normal periodontium to tenths of a millimeter in compromised situations. Therefore, the stiffer implants may be subjected to an increased charge of load.

The load on implants may be substantially influenced by occlusal contact and cusp inclination of the restoration. If contact is allowed during excursive motions of the jaw, the cusp inclination determines the relation between axial forces and lateral forces: the less the inclination, the smaller the lateral forces. The more centric the occlusal contact, therefore, the smaller the bending from the axial forces (Fig 2). Finally, a parafunction such as bruxism or heavy clenching may introduce both a substantial increase in force level, as well as number of loading cycles.

Using only one free-standing implant to support a fully functioning molar can be questioned with reference to the possible bending overload situation described above. Bone loss and implant fractures have been reported for this type of restoration.[4] A natural way of diminishing the potential overload in this situation is to direct the occlusal contact location at a centric position on the tooth, thus reducing the bending on the implant, as well as establishing a light contact for reducing the occlusal force on the implant.

Another way of controlling this load situation is to support a single-molar replacement with two implants. This can basically eliminate the mesiodistal bending and double the support capacity in the buccolingual direction (Fig 3). However, a possible clinical drawback with the two implant–supported molar is the fact that space adjacent to the implant is rather narrow, a few millimeters only, which may lead to cleaning difficulties for the patient and may theoretically influence the bone remodeling.

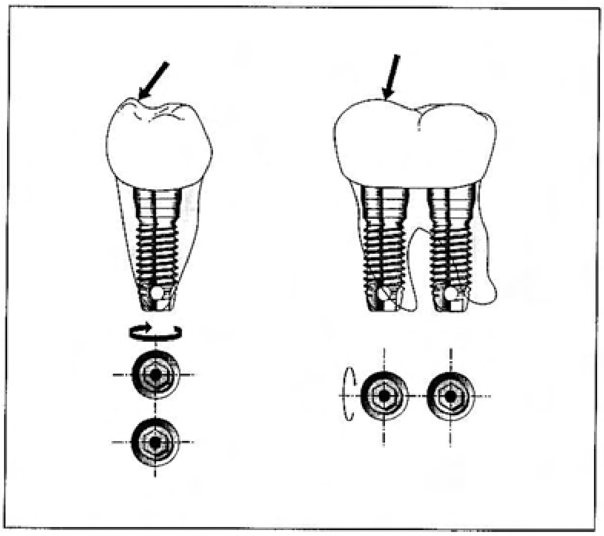

Fig 3 A single molar supported by two implants basically eliminates the mesiodistal bending and in essence doubles the support capacity in the buccolingual direction.

The clinical feasibility of using two implants to support a molar restoration has been reported previously.[5] The present study presents a retrospective comparative analysis in which single molars have

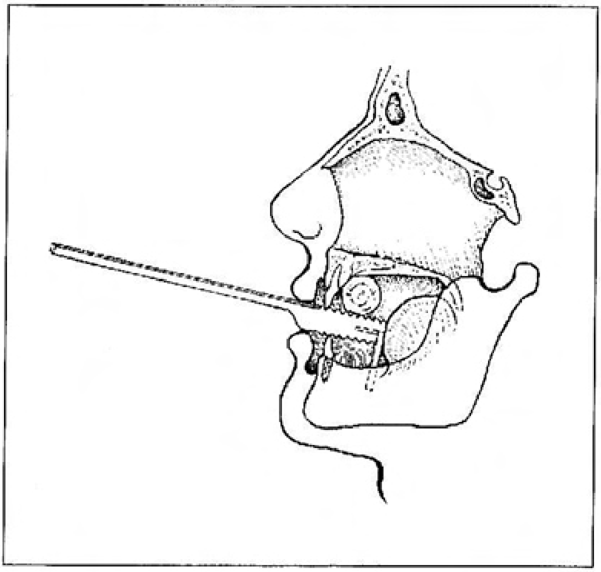

Fig 6 Technique used for radiograph fixation. (Adapted from Hollender L, Rockler B, Strid K-G. Instructions for the production of radiographs to be examined by computer-aided image analysis [brochure]. Göteborg, Sweden: Department of Oral Diagnostic Radiology, University of Göteborg; Göteborg, Sweden: Institute for Applied Biotechnology, 26 July 1983.)

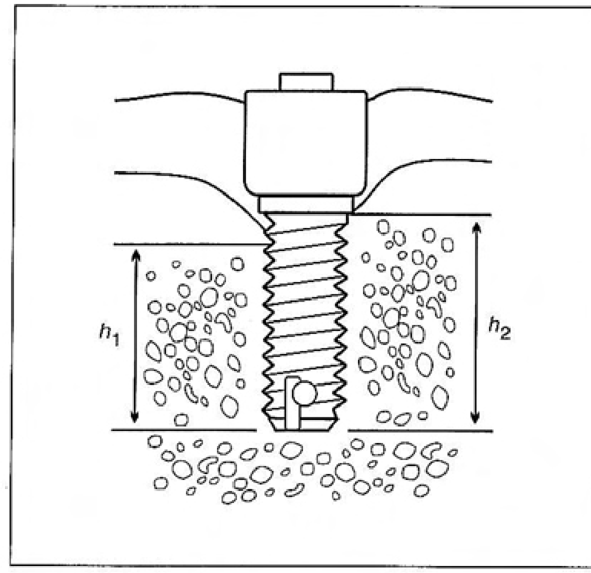


Fig 7 Measurement of marginal bone height. Mean of mesial and distal values (1/2 [$h_1$ + $h_2$]) was used for each implant. (Adapted from Lindquist L, Rockler B, Carlsson G. Bone resorption around fixtures in edentulous patients treated with mandibular fixed tissue-integrated prostheses. J Prosthet Dent 1988;59:59–63.)

The combined mesial and distal bone loss was 0.10 mm (standard deviation [SD] 0.20 mm) for the first group (n = 21) and 0.24 mm (SD 0.20) for the second group (n = 25). When comparing marginal bone loss for the above groups, there was a statistically significant difference between the groups ($P < .05$). Table 5 gives the values of the combined bone loss in intervals for each group, and Fig 8 shows the percentage of the number of implants in each interval.

The Sulcus Bleeding Index remained relatively constant from presurgery through the 1- and 3-year follow-ups, and no periodontal pockets were found. The soft tissue around the implants appeared to be very healthy.

Nine of 21 (43%) patients in group 1 (one implant) and 21 of 25 (84%) in group 2 (two implants) had no complications over the 3-year period (Table 6). Prosthesis mobility related to screw loosening was the most frequent complication with 7 of 21 (33%) in group 1 and 2 of 25 (8%) in group 2. Other less frequent complications were loose abutment, fracture of the abutment screw, and porcelain fracture. Altogether 10 of 21 (48%) of the prostheses in group 1 became mobile, including completely loose or fractured screws. The corresponding number for group 2 was 2 of 25 (8%).

In group 1, fracture of the abutment screw occurred in one patient (Interlocking Standard abutment) and loose abutments in two patients (Interlocking Standard abutments), but no fractures occurred in group 2. Only two patients had porcelain fracture, one in the first group and one in the second group. In both of these patients, the opposing occlusion was natural dentition.

## Discussion

Only one implant was lost during 3 years of follow-up. The nonintegrated implant was 10 mm in length and placed in type 3 quality bone. No reasonable explanation for this finding could be concluded, since this implant was placed in a patient with a noncontributory medical history.

The marginal bone loss after 3 years of function was low: 0.10 mm for the group with one implant and 0.24 mm for the group with two implants. These results compare closely with those of other reported studies[11,12] involving Brånemark implants. When comparing marginal bone loss for the above groups, there was a statistically significant difference between the groups. One hypothesis is that the decreased access between the implants in group 2 could be a contributing factor. However, this was not supported by clinical observations or the bleeding index, which both demonstrated very healthy soft tissue in this area. Also noteworthy is the fact that patients for the two groups were not randomly chosen, and the difference may be the result of factors

**Table 3** Distribution of Implants According to Position and Size

| | Size (mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 7 | 10 | 13 | 15 | 10 × 4 | Other* | Total |
| Group 1 (n = 22) | | | | | | | |
| Posterior maxilla | 0 | 2 | 0 | 2 | 0 | 0 | 4 |
| Posterior mandible | 0 | 8 | 7 | 0 | 2 | 1 | 18 |
| Group 1 total | | | | | | | 22 |
| Group 2 (n = 25) | | | | | | | |
| Posterior maxilla | 0 | 2 | 0 | 0 | 1 | 1 | 4 |
| Posterior mandible | 0 | 22 | 17 | 0 | 2 | 5 | 46 |
| Group 2 total | | | | | | | 50 |

*Implants were 3, 4, or 5 mm in diameter, and all were greater than 10 mm in length.

endodontic failure in 24 (51%), periodontitis in 12 (26%), trauma in six (13%), and advanced carious lesions in four (9%).

No provisional prosthesis was used by the patients during the healing period, but a conversion prosthesis technique[7] was utilized after the second-stage surgery until the final restoration was fabricated. The restorative material used for the final restoration was porcelain fused to gold. Occlusal function for all molars was established utilizing a firm centric contact with little pressure in lateral excursions. This condition was checked at patient revisits every 6 months and adjusted if needed. At each visit, mobility of the prostheses was assessed regarding implant stability and screw loosening. If the prosthetic screw could be retightened, the prostheses were considered mobile. If the screw was completely loose or fractured, this condition was registered separately

Radiographic examination was routinely performed according to the principles described previously for stereoscopic radiographic techniques[8,9] (Figs 6 and 7). The radiographs were taken 1 week after abutment connection, 6 and 12 months postoperatively, and once every 12 months thereafter. The radiographs taken 1 and 3 years after loading were used in the present study. Radiographs were analyzed with respect to bone loss and change of density of the bone around the implants. The marginal bone height of each implant was measured mesially and distally by using the implant threads as the dimensional reference. The numerical mean of the mesial and distal measurements was used as a value for each implant. The marginal bone loss (1 to 3 years) was calculated for each site by comparing the 1-year values of marginal bone loss with the corresponding 3-years values. When comparing bone loss (1 to 3 years) for the two groups, a two-sample $t$ test was used, and the data between the groups were compared with Student's $t$ test. For the two-implant group, one implant was randomly selected from each prosthesis for this comparison.

**Table 4** Distribution of Abutments

| Type | Height (mm) | No. |
|---|---|---|
| Group 1 (n = 21) | | |
| Single-tooth abutment | 1 | 4 |
| | 2 | 2 |
| | 3 | 2 |
| Interlocking abutment | 4 | 3 |
| External hex abutment | 5.5 | 0 |
| | 7 | 0 |
| CeraOne abutment | 1 | 5 |
| | 2 | 2 |
| | 3 | 1 |
| | 4 | 0 |
| Custom cast (UCLA) | | 2 |
| Group 2 (n = 25) | | |
| EsthetiCone | 1 | 15 |
| | 2 | 6 |
| | 3 | 1 |
| Standard abutment | 3 | 17 |
| | 4 | 8 |
| Angulated abutment | 4 | 2 |
| Single-tooth abutment | 1 | 1 |

Soft tissue condition according to Mühlermann and Son[10] was recorded before treatment, reflecting an index of 0.0 to 0.3. It was checked again at the first- and third-year follow-up.

## Results

One patient in group 1 (one implant) was withdrawn from the study because of implant loss during healing. At the 1- and 3-year clinical examinations, all remaining 71 implants supporting the single-tooth restorations continued to be stable and in function for the other 46 patients. As a result of the loss of the one implant in the first year, the success rate was 98.6%. During years 2 and 3, no further implants were lost, resulting in continuously stable prostheses and a cumulative success rate of 98.6% after 3 years of function.

**Table 5** Marginal Bone Loss Between 1 and 3 Years

| Marginal bone loss | Group 1 (21 implants) | Group 2 (25 implants) |
|---|---|---|
| < 0.0 | 14.3% | 4.0% |
| 0 | 9.5% | 8.0% |
| 0.0–0.5 | 76.2% | 76.0% |
| 0.5–1.0 | 0% | 12.0% |
| > 1.0 | 0% | 0% |

**Table 6** Complications*

| | No. of group 1 patients | No. of group 2 patients |
|---|---|---|
| No complication | 9 (42.9%) | 21 (84.0%) |
| Prosthesis mobility | 7 (33.3%) | 2 ( 8.0%) |
| Fracture of abutment screw | 1 ( 4.8%) | 0 |
| Prosthesis unsatisfactory | 1 ( 4.8%) | 1 ( 4.0%) |
| Abutment loose | 2 ( 9.5%) | 0 |
| Porcelain fracture | 1 ( 4.8%) | 1 ( 4.0%) |
| Other | 1 ( 4.8%) | 2 ( 8.0%) |

*Some patients have had more than one complication.

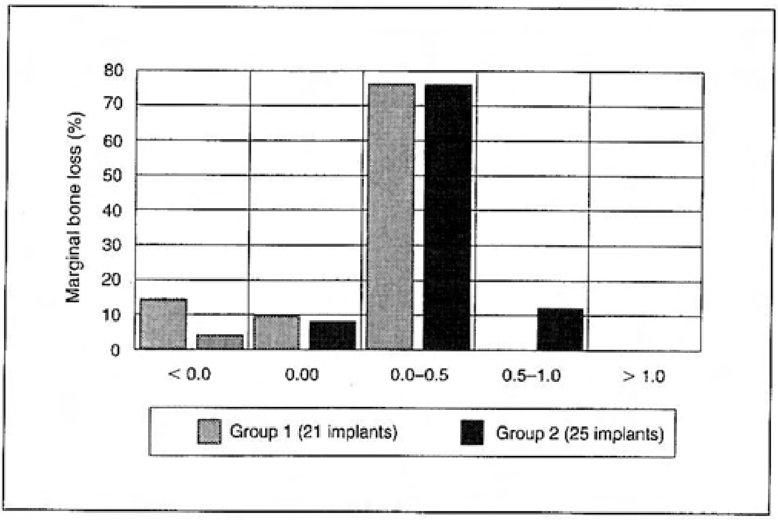


**Fig 8** Distribution histogram of bone loss per interval in the two groups.

other than the number of implants per site. From Fig 8, a trend may been seen. The majority of implants in both groups had bone resorption in the intervals 0.0 mm and 0.0 to 0.5 mm, but group 1 had more implants with bone ongrowth (0.5 to 1.0 mm). In any case, the number of patients was too small to allow any clinically relevant conclusion considering that the amount of resorption was minor.

The previously reported success rate in the multicenter prospective study[1] for single-tooth replacement was 97% after 3 years. In that study, no implant was placed in the maxillary molar region, and only five implants were placed in the mandibular molar area, of which three were followed-up for 3 years. Results from the present study demonstrate an equivalent level of success for the single-molar replacement in accordance with results from a 2-year study[3] on single-implant single-molar replacement.

The frequency of screw loosening in the multicenter study[1] was lower compared to that in the one-implant group of the present study, but higher compared to that in the two-implant group. The frequency of screw loosening for the 2-year study[3] on single-implant single-molar replacement was at the same level as for the one-implant restorations in the present study. These results support the biomechanical advantage of the two-implant–supported alternative for molar replacement.

Screw loosening occurred primarily in the single-implant situation, which was expected based on its more challenged biomechanical situation. These problems were mostly seen with the Interlocking Standard abutment, which experienced five occasions of loosening on the three abutments. One of the two UCLA and one of the eight Single-Tooth abutments loosened. However, all eight CeraOne abutments remained stable. All loose and fractured screws occurred with the Interlocking Standard abutment (Nobelpharma AB). This outcome clearly demonstrates the potential screw-loosening problem in single-implant situations using abutments intended for multiple-implant restorations. It also confirms the improved screw-joint design of the CeraOne, which is designed for single-implant situations.[1]

Screw loosening may also be an indicator of overload, and strengthening the screw joint may induce higher stress to the implant-bone interface.[4] Therefore, the concept of reducing implant-bone stress by means of two implants is a biomechanically more advantageous solution, not only for minimizing the mechanical problems such as screw loosening, but primarily for its all-over lower stress on implant and bone.

## Conclusion

This clinical study of single molars supported by one or two implants demonstrates the feasibility of this therapy. Marginal bone levels were stable during the 3 years of follow-up, and the success rate was 99%. A prerequisite for molar replacement with a single implant seems to be appropriate occlusal adjustment.

Even if centric and light occlusal contact was implemented, a relatively high degree of mechanical loosening of the prostheses was recorded for the single-implant restoration, indicating potential overload. To what degree these biomechanical limitations could be overcome with stronger components can only be speculated. To what extent even wider implants will be effective in this therapy situation remains to be demonstrated. However, a logical approach is to use the slightly wider 4-mm-diameter implant for posterior regions. This is especially important for matching the higher strength of a CeraOne abutment if this unit is used for the prosthetic reconstruction.

Although it has been demonstrated that the single-implant, single-molar restoration is a possible alternative, it appears that the use of two implants to replace a single molar provides distinct biomechanical advantages. A drawback with two implants for this support, however, is the need for a minimum of 12 mm of space to accommodate two implants, and this is not always available.

## Acknowledgments

The authors wish to thank Christina Bergström (Department of Clinical, Nobelpharma AB) for her statistical analysis; Chris Raines for table preparations; and Liz Kirk for manuscript preparation.

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