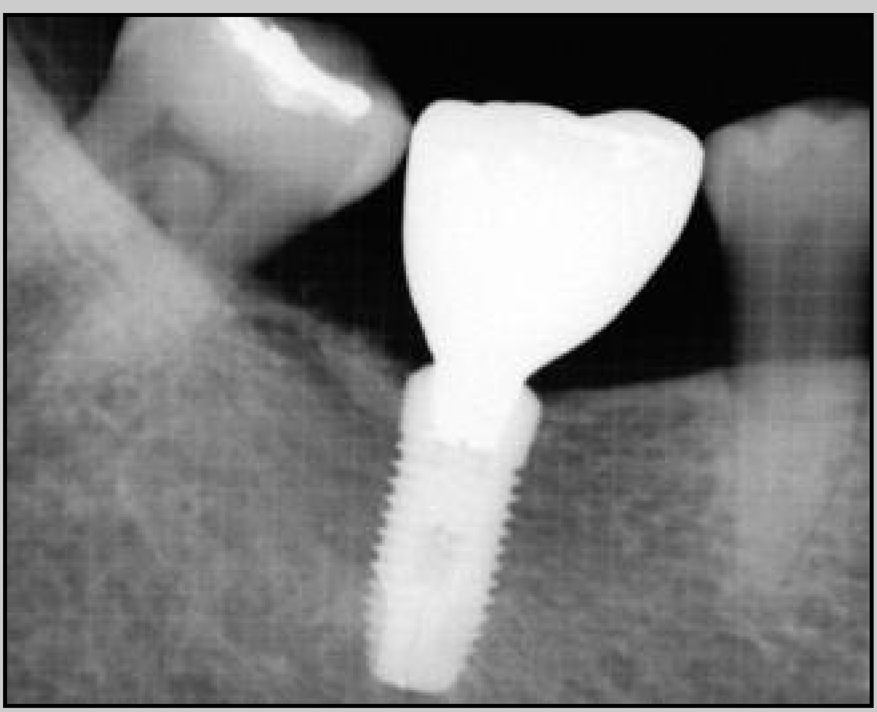
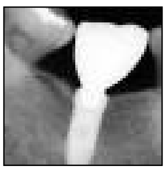


Prognosis of Single Molar Implants: A Retrospective Study



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The purpose of this study was to evaluate the short- and mid-term prognosis of maxillary and mandibular single molar implants, prosthetic complications, and factors mediating the effects seen on them. Eighty-seven patients were enrolled consecutively in this study and 96 implants were placed into a single molar defect site by one oral and maxillofacial surgeon from March 2004 to December 2006. Primary osseointegration failure developed in two implants and delayed implant failure occurred at four implants. The fraction surviving interval was 97% to 100%, and at the last follow-up observation, the cumulative survival rate was 91.1%. All failed implants occurred in second molar sites, and the failure rate, according to implant site, showed a significant difference. Prosthetic complications, such as screw loosening, showed a significant correlation to the mesiodistal cantilever. Furthermore, crestal bone loss 3 years after loading was 0.2 mm on average and a very stable result was obtained. Based on the results, the risk of failure for maxillary and mandibular single molar implants is high and the possibility of developing prosthetic complications during loading is also high. Therefore, to minimize the cantilever, implants must be placed precisely and followed carefully and maintained for a long period of time. (Int J Periodontics Restorative Dent 2010;30:401–407.)

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Posterior single-tooth implant restorations are subjected to an increased risk of bending overload.[1] The maxillary and mandibular molar areas exert strong masticatory forces and contain important anatomical structures, such as the maxillary sinus and the inferior alveolar canal. Bite forces are larger in men than in women and increase monotonically along the arch until the first or second permanent molar.[2]

Single molar implant surgery may be difficult because of the limiting effect of the surrounding anatomical structures. Even after completion of the prosthesis, the risk of the induction of a prosthodontic complication and delayed implant failure by strong masticatory forces or oral parafunction is speculated to be high. Prosthodontic functional complications include screw loosening, implant component fracture, and loose contact with the adjacent teeth. On the other hand, the use of two implants increases the anchorage surface area twofold while reducing the rotational force. Thus, the incidence of screw loosening is reported to be decreased noticeably.[3,4] However, it has been reported that oral hygienic problems develop when using two implants.

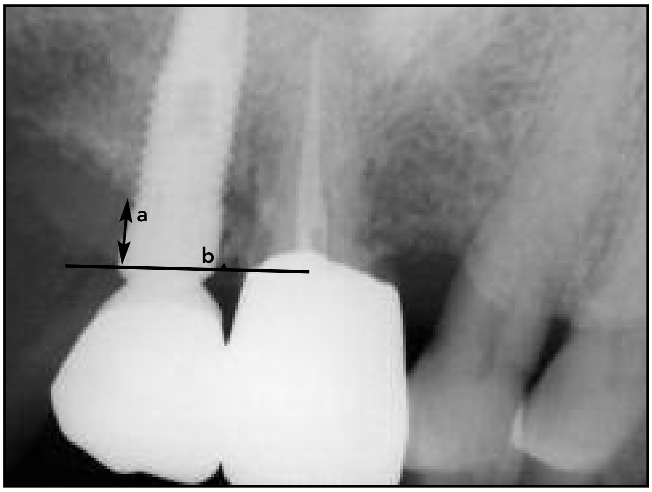


Fig 1 *The method of measuring crestal bone loss. On the mesial and distal side, the resorption volume from the top of the implant to the first bone contact area was measured. Then the average was calculated.* (a) *Distal bone loss;* (b) *mesial bone loss.*

On the other hand, Langer et al[5] reported that if 5-mm-wide implants are used, the procedure is simple, costs are reduced, masticatory forces are better withstood, and prosthodontic complications decrease.

Clinical studies on single molar implants have been reported by several investigators.[1,3,4] Nonetheless, reports that have analyzed different molar areas are not abundant. Particularly, Koreans, who favor hard foods such as kimchi, gakdugi, squid, and ribs, deliver a strong masticatory force to the molar area. Kim et al[6] examined the subjective food intake ability in relation to the maximum occlusal force among Korean adults. The five key food items selected were dried cuttlefish, raw carrot, dried peanut, cubed white radish kimchi, and caramel. The correlation coefficient between the food intake ability and occlusal force with these items was 0.51 ($P < .01$). In addition, it was speculated that if parafunctional forces such as bruxism and clenching were delivered, single molar implants may show a high risk of complication and failure. Therefore, this retrospective clinical study was conducted to evaluate the prognosis of each molar area in Koreans whose masticatory force is strong, and to analyze the factors mediating the effects seen on prosthetic complications and failure.

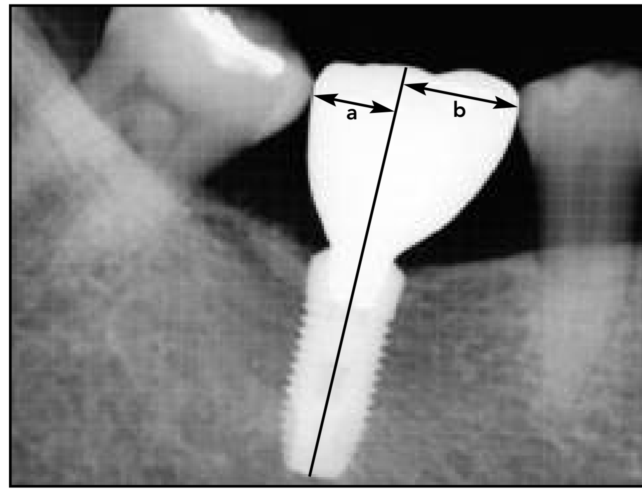
Method and materials

Ninety-six Implantium implants (Dentium) were placed in single molar defect sites of 87 patients (49 men, 38 women) between March 2004 and December 2006. Patients ranged from 22 to 68 years of age (mean, 48 years). Seventeen patients suffered from a systemic disease; all maintained a stable condition throughout medical treatment. Smoking status was not evaluated. Based on patients' medical records and radiographs, the following criteria were examined: implant width and length, accompanying surgery performed at the time of implant placement, bone graft materials and the type of barrier membrane, crown-implant ratio, the mesiodistal cantilever, status of the opposing tooth, type of suprastructure, crestal bone loss, and implant failure and prosthetic complications.

Crestal bone loss

Periapical radiographs (Heliodent, Sirona) were taken using a short-cone paralleling technique. The crestal bone level in the vicinity of the implant was measured immediately after surgery at baseline and at 1, 2, and 3 years after prosthesis delivery. The crestal bone loss from the top of the implant to the first bone contact area was measured on the radiographs (Fig 1). The magnification power was adjusted using the length of the implants placed. The mesial and distal sides were measured and the mean value was calculated.[7]

Fig 2 *The method of measuring the cantilever. The length of "b" (midline to mesial aspect of the crown) was longer than the length of "a" (midline to distal aspect of the crown) by 2 mm. Thus, this implant was defined as having a mesial cantilever.*



Crown-implant ratio

After completion of the definitive prosthesis, the ratio of the crown and implant lengths were calculated using panoramic or periapical radiographs.

Mesiodistal cantilever

After completion of the definitive prosthesis, panoramic or periapical radiographs were again used to determine the presence or absence of a mesiodistal cantilever. From the midline parallel to the long axis of the implant, the distance to each mesiodistal side of the maximum convexity of the crown was measured. Implants with more than a 2-mm difference were considered to be cantilevered (Fig 2).

Statistical analysis

The type of suprastructure, crown-implant ratio, cantilever, and status of the opposing tooth were analyzed for their relationship with the patient's outcome, including crestal bone resorption, survival, and prosthodontic complications. A chi-square test was used to assess the significance of the association between the clinical factors. Also, Student *t* tests were used to evaluate the differences in crestal bone resorption between groups with and without prosthetic complications. The timeline was from the date of implant surgery to the end of the study. Survival curves were estimated using the Kaplan-Meier method. Statistical analysis was performed using the SPSS system (version 15.0, SPSS). A *P* value $< .05$ was considered significant.

Results

Ninety-six implants were placed: 35 in the mandibular second molar area, 30 in the maxillary first molar area, 17 in the mandibular first molar area, and 14 in the maxillary second molar area. Regarding the length of the placed implants, 10 implants were 8 mm long, 44 implants were 10 mm long, 37 implants were 12 mm long, and 5 implants were 14 mm long. Regarding diameter, 70 implants were 4.8 mm, 21 implants were 4.3 mm, and 5 implants were 3.8 mm. Eighteen implants were nonsubmerged and 78 were submerged.

The healing period from implant placement to the second operation or the first impression taking was a minimum of 1 month to a maximum of 14 months (mean, 4.5 months). The healing period in the maxilla ranged from 4 to 12.5 months (mean, 6 months); healing in the mandible ranged from 1 to 14 months (mean, 3.3 months).

Some implants required a combined surgical procedure to be placed: 18 required sinus bone grafts and implant placement, 12 required bone-added osteotome sinus floor elevation, 4 required osteotome sinus floor elevation, and 34 required guided bone regeneration; 28 implants did not use a combined surgical approach.

Postoperative complications and failures

The postsurgical follow-up period lasted 12 months to 48 months (mean, 24.7 months). In terms of postsurgical complications, wound dehiscence occurred in six implants in six patients. In two patients, two implants failed during the initial osseointegration.

Regarding the definitive prosthesis used for 94 implants, there were 63 gold crowns and 31 porcelain-fused-to-gold crowns. Six implants failed throughout follow-up and the survival rate of each follow-up period was 97% to 100%. Nevertheless, 1 implant was removed between 3 and 4 years. Thus, the cumulative survival rate was 91.1%. In five patients, an implant had to be placed again and the prosthesis treatment was completed successfully. In addition, one patient had a failed implant at the right maxillary second molar site; placement was canceled for this patient..

Examining the failure rate of each implant site, four implants failed at the maxillary second molar site and two implants failed at the mandibular second molar site; all failures were observed at the second molar. A significant difference could be observed regarding implant site ($P = .002$).

Crestal bone loss and complications after prosthesis delivery

After delivery of the definitive prosthesis, a minimum of 0 mm and a maximum of 1.4 mm of bone loss was evident (mean, 0.1 mm). After 2 years, a minimum of 0 mm and a maximum of 1.6 mm of bone loss was seen (mean, 0.13 mm). The mean crestal bone loss measured after 3 years was 0.2 mm.

Thirty-one different types of complications developed in 26 patients.

Table 1 Cantilever and prosthetic complications

Cantilever	Complications No	Yes	Total
Yes	27	11	38
No	47	5	52
Total	74	16	90

Screw loosening was the most prevalent (n = 12), followed by food retention (n = 6), delayed implant failure (n = 4), peri-implant gingivitis (n = 3), loose contact (n = 2), soft tissue biting (n = 2), prosthesis dislodgement (n = 1), and abutment fracture (n = 1).

Factors mediating effects on prosthetic complications

Crown-implant ratio

The mean crown-implant ratio of 90 implants was 0.96 (range, 0.5 to 1.6). Implants were divided into groups with a crown-implant ratio > 1 and a crown-implant ratio < 1 and then compared. It was found that prosthetic complications did not correlate to the crown-implant ratio ($P > .05$).

Mesiodistal cantilever

A significant difference in the development of prosthetic complications was observed between groups with and without a cantilever ($P = .016$) (Table 1).

Site

The incidence of prosthetic complications according to each site was not statistically nor significantly different ($P = .631$).

Crestal bone loss

The volume of the crestal bone loss in the group without prosthetic complications was an average of 0.231 mm; the group with prosthetic complications experienced a crestal bone loss of 0.298 mm. A statistically significant difference was not detected.

Type of crown and status of opposing tooth

The type of single-implant crown used and the condition of the opposing tooth were not associated with prosthetic complications.

Discussion

The Implantium implant used in this study is a root-form implant with a sandblasted and acid-etched surface. For the superior portion, a double microthread design was chosen and the connection method for the abutment-implant was an internal conical sealing connection. Thus, the final cumulative survival rate was 91.1%, which was shown to be slightly low. However, the survival rate at each follow-up period was shown to be 97.92% to 100%. All implant failures were seen in the maxillary and mandibular second molar area.

The authors speculated that two factors heightened the risk of implant overload to the maxillary and mandibular second molar area, although pertinent literature could not be found: *(1)* it is possible that the masseter muscle involved in mastication exerts a strong force to the lateral side of the second molar and *(2)* the single implant at the first molar site could distribute the delivered masticatory force to the adjacent premolar and second molar. However, the second molar could expect to experience the distribution effect only from the proximal first molar and thus, it may be disadvantageous dynamically.

Food retention occured most frequently at implants in which the oral hygiene ability of the patient deteriorated. It is not generally a problem and it is often resolved over time. Soft tissue biting occurs in cases where the shape of the definitive prosthesis was malformed because the implant was placed inappropriately.[8]

Single-implant prosthetic complications that developed frequently during the follow-up period included porcelain fractures, screw loosening, and cementation failure. Prosthetic complication rates were reported to vary between 0.9% and 17.7%.[9–11]

The causes of screw loosening stem from occlusal overload, implant location, inadequate fit of the prosthesis, design of the prosthesis, progressive bone loss, metal fatigue, implant diameter, manufacturing defects, and galvanic activity.[12,13] Particularly, screw loosening has been reported to occur frequently in the molar area. Additionally, the frequency in the maxilla is more than two times higher than the mandible.[14,15] In this study, 13.3% of screw loosening events occurred at various follow-up periods, from 1 month after prosthetic delivery to 33 months. In all cases, it was resolved by removing the crown, washing the inside, and retightening the screws with a torque driver. No implants that suffered from screw loosening failed and severe crestal bone loss was not induced.

Implant component fractures have been reported to occur frequently in the posterior region of partially edentulous patients.[16,17] In this study, implant fractures were not observed. However, an abutment screw fracture developed in a single maxillary left first molar implant with a mesial cantilever 12 months after loading.

The causes of loss of appropriate contact with the adjacent tooth are: contact surface abrasion of the adjacent tooth, mobility of the adjacent tooth, "jiggling" movement caused by lateral occlusal contact with the adjacent tooth, imprecise strength and location of the adjacent contact surface, shape, the wedge effect of the cusp of the opposing tooth, and screw loosening.[8] In this study, two implants suffered from inappropriate contact, which was solved by the addition of porcelain and refabrication of the crowns.

The main limitation of this study was the substantial variability in a number of clinical factors that might present different conditions for different implants, such as submerged or nonsubmerged procedures, varying healing periods, substantial differences in graft type or guided bone regeneration, or the varying diameters of the implants. A prospective clinical study is currently being conducted to understand and report on each clinical outcome of maxillary and mandibular first and second molar single implants with many standardized variables; the results will be reported in a later paper.

Conclusion

Based on the results of this study, it is assumed that the risk of failure with maxillary and mandibular single molar implants is high and the possibility of developing prosthetic complications is also high, even during loading. Therefore, to minimize the cantilever, one must place an implant precisely and perform long-term and careful follow-up and maintenance.

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