<Original Article>

Factors Associated with the Stability of Two-part Mini-implants for Intermaxillary Fixation

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• Abstract

Two component orthodontic C-implants have been introduced as intermaxillary fixation (IMF) screws in cases of periodontal problems with bone loss, severely damaged teeth, or short roots. This retrospective research sought to investigate the complications and risk factors associated with the failure of two-part C-implants for IMF cases and to show the possible indications compared to one-component mini-implants. The study sample consisted of 46 randomly selected patients who had a total of 203 implants. Pearson chi-square tests of independence were used to test for associations among categorical variables. At least 19 of the total 203 implants failed (9.3%). There was no significant difference in implant failure due to gender, oral hygiene, and placement, although a significant difference due to soft tissue characteristics and root contact was observed.

The two-component design of the mini-implant is reliable for difficult IMF cases. Note, however, that the factors influencing implant failure were found to be age, root damage, and condition of soft tissues.

• Key word : Intermaxillary fixation (IMF), Mini-implant, C-implant, risk factor, Orthognathic surgery

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Introduction

Intermaxillary fixation (IMF) has been used for fracture and orthognathic surgery to provide indirect stabilization in the maxilla and mandible. Many clinicians have introduced various methods for easier and stabler IMF[1-6]. Among them, using titanium mini-implants has been reported to be the easiest and safest method[3-7]. With smaller and various designed orthodontic mini-implants introduced in recent years, IMF can be made more efficient compared to previously developed surgical mini-screws. Mini-implants have the advantage of easy placement and removal. They also enable patients to maintain good oral hygiene easily and cause less damage to the oral mucosa. These implants are small enough for placement in any surface of the alveolar process even in interdental areas as well as relatively inexpensive[3-7].

Note, however, that most currently used mini-implants have problems such as fracturing or deformation during placement and/or removal, root injuries and adjacent soft tissue infection and inflammation, and early failure of implants[8-11]. Even though the one-component implant has a head part for elastic application, it is too short to hold multiple elastics.

To compensate for these disadvantages and achieve efficient IMF, the authors chose a two-part design mini-implant called C-implant and applied it during the preoperative, operative, and postoperative periods[12-14]. Consisting of the head and screw, this two-component system is held together by mechanical friction (Fig. 1)[12]. This is different from the one part mini-implant since the screw is implanted first; the head, which can come in various sizes, is inserted later (Fig. 2). The two-component C-implant does not affect the incision line and suture during the two-jaw surgery[14]. In some cases, the mini-implant must be placed in the non-keratinized tissue if the interradicular space is too narrow[7]. IMF wire or elastics application for this type of mini-implant is useful in these cases. In other words, an advantage of the two-component C-implant is that different head sizes can be chosen for the screw for poor periodontal conditions, damaged teeth, and narrow interradicular spaces. Note, however, that there are limited studies on the causes of two-part C-implant failure. Likewise, the lack of information hardly makes it clinically useful. Therefore, this retrospective study sought to investigate the complications and risk factors associated with the failure of two-component C-implants in complex IMF cases and show the possible indications compared to one-component mini-implants.

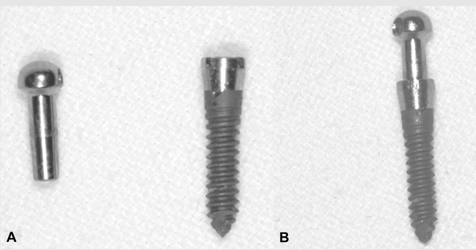

Fig 1. Two-part C-implant with separate head and screw parts. The screw part is placed, and the head part is joined mechanically.

Seong-Hun Kim et al : Factors Associated with the Stability of Two-part Mini-implants for Intermaxillary Fixation. J Kor Dent Sci 2009.

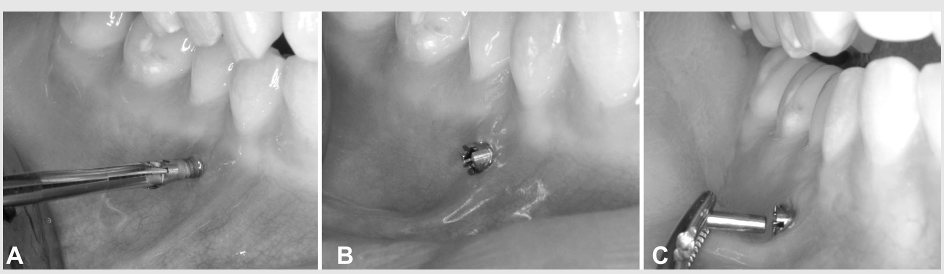

Fig 2. C-implant placement procedure. A. The screw part of the mini-implant is placed after cortical penetration using guide drill with diameter of 1.5mm. B. After screw part placement. C. Titanium head part is assembled by friction.

Seong-Hun Kim et al : Factors Associated with the Stability of Two-part Mini-implants for Intermaxillary Fixation. J Kor Dent Sci 2009.

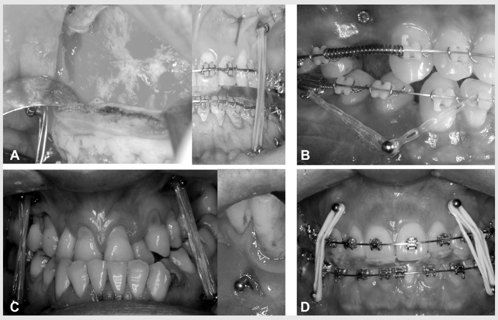

Fig 3. Applications of C-implant for complex IMF patients. A. The long head part of the mini-implant does not affect the incision line and suture during LeFort I surgery or one-jaw surgery with genioplasty/ B. Postoperative orthodontic treatment is performed using the same mini-implants for skeletal anchorage after IMF. C. Implantation of mini-implant on more than two non-keratinized tissue areas. D. Continuous wearing of multiple elastics was necessary after IMF.

Seong-Hun Kim et al : Factors Associated with the Stability of Two-part Mini-implants for Intermaxillary Fixation. J Kor Dent Sci 2009.

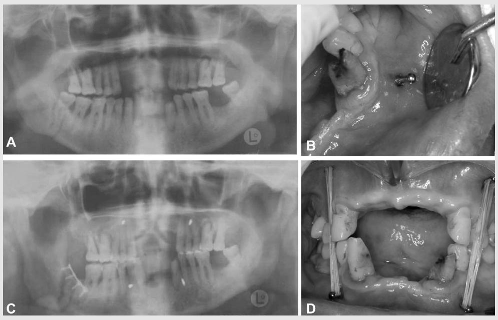

Fig. 4. IMF for severe periodontal condition and missed dentition in mandible fracture surgery (53 years 4 months, male). A. Pretreatment panoramic radiograph. B. Two-component C-implant is placed on the non-keratinized tissue area. C. Post-surgery panoramic radiograph. D. Long head parts were used for heavy elastics application, and sufficient force can be applied for reduction and minimum gingival irritation.

Seong-Hun Kim et al : Factors Associated with the Stability of Two-part Mini-implants for Intermaxillary Fixation. J Kor Dent Sci 2009.

Materials and Methods

Subjects and IMF selection

A total of 203 C-implants were placed in the samples consisting of 46 patients (38 men and 8 women) whose ages ranged from 16 to 67 years and who were undergoing intermaxillary fixation (IMF) with two-part mini-implants for fracture and orthognathic surgery at the Department of Oral and Maxillofacial Surgery, Catholic University of Korea, Uijongbu St Mary's Hospital from September 2004 to February 2006 (Table 1). The purpose of the study was explained to the patients, and they agreed to participate in the research. Informed consent was obtained from every patient prior to implantation. We have followed the principles outlined in the Declaration of Helsinki.

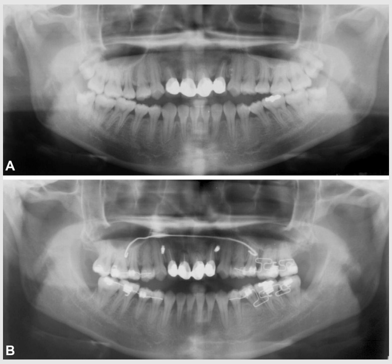

Fig. 5. A 27-year-old woman with anterior open bite and upper anterior root resorption. A. Initial panoramic view. B. After C-implant placement between the upper lateral incisor and canine.

Seong-Hun Kim et al : Factors Associated with the Stability of Two-part Mini-implants for Intermaxillary Fixation. J Kor Dent Sci 2009.

All of them met at least one of the following criteria: 1) two-jaw orthognathic surgery or one-jaw surgery with genioplasty (Fig. 3A); 2) postoperative orthodontic treatment was planned using the same mini-implants for skeletal anchorage after IMF (Fig. 3B); 3) implantation on more than two non-keratinized tissue areas (Fig. 3C); 4) continuous wearing of elastics was necessary after IMF (Fig. 3D); 5) severe periodontal condition (Fig. 4), and; 6) unable to secure IMF due to missing teeth, dental caries, and root resorption (Figs. 5 and 6).

IMF Procedures

The mini-implant position was determined by the availability of alveolar bone, fractured lines, and surgery design in each case. The two-component C-implant (Cimplant Co., Seoul, Korea) used for IMF had diameter of 1.8mm and length of 9.5mm; it measured 2mm in the neck area[8-9]. The entire surface except the upper 2mm, was sandblasted, large-grit, and acid-etched (SLA) for optimal osseointegration. At least 4~6 C-implants were used depending on the deviation of fracture sites and types of orthognathic surgery. The position of the screw relative to fracture patterns was as follows: between the canine and

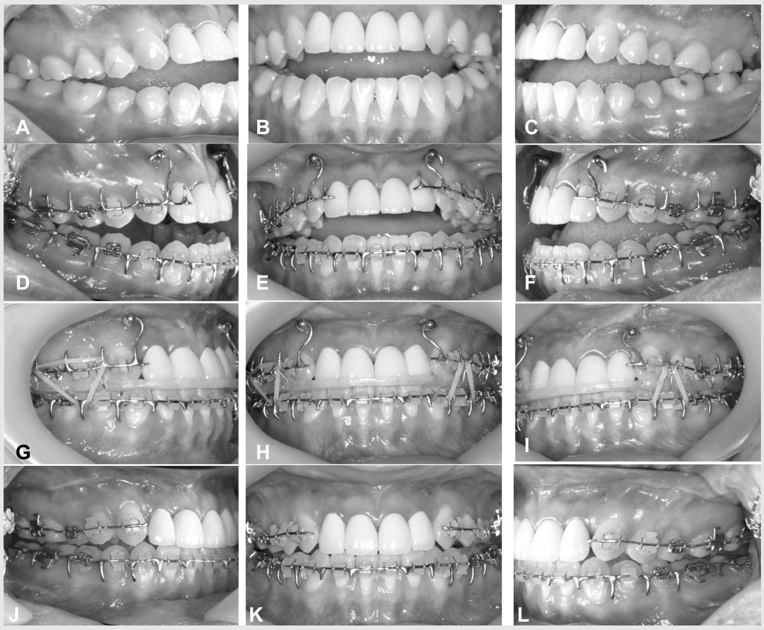

Fig. 6. Intraoral photographs of the treatment progress. A to C. Pretreatment. D to F. Preoperative view. G to I. Surgical wire was applied to the C-implant hole after surgery. J to L. After C-implant removal.

Seong-Hun Kim et al : Factors Associated with the Stability of Two-part Mini-implants for Intermaxillary Fixation. J Kor Dent Sci 2009.

first premolar in simple symphyseal fracture cases with four mini-implants; triangular implantation using a total of six mini-implants (two in the upper and one in the lower jaw or vice versa on each side) in cases of mandibular body fracture or Bisagittal Split Ramus Osteotomy (BSSO), two jaw surgery. When additional fixation was needed, an arch-bar was applied to the affected area.

Following local anesthesia, a guide drill with diameter of 1.5mm (Stryker-Leibinger Co., Freiburg, Germany) using a low-speed hand piece was utilized under irrigation with isotonic saline solution. After drilling to the cortical bone depth, the screw part was inserted manually into the prepared site, and the head part was connected to the implant body immediately after insertion. Radiographs were immediately taken after insertion to evaluate the proper location and root damage to the neighboring teeth. The C-implants were usually removed 3 weeks after operation in the fracture patients group and 6 weeks after operation in the orthognathic surgery group. For postoperative orthodontic cases, however, 24 C-implants remained at the end of treatment. The mean periods of IMF application in fracture surgery patients were 35 ± 19.7 days, and those in orthognathic surgery patients, 131.9 ± 96.5 days.

Determining Success

The success criteria for an implant were defined by the absence of peri-implant tissue inflammation and implant mobility during the postoperative period. “Mini-implant mobility” was defined as movement of over 1mm using an explorer probing the hole of the head part. The “postoperative period” refers to the time when elastics were used for IMF after surgery and during the postoperative orthodontic treatment; the C-implant was used as skeletal anchorage. After this treatment, all the C-implants were removed. Patient gender, age, oral hygiene and implant placement sites, characteristics of the soft tissue at the implant emergence site (keratinized versus non-keratinized), and degree of root-to-implant contact were recorded for each patient. Complications associated with the mini-implants were evaluated on every follow-up visit.

Statistical Analysis

Pearson chi-square tests of independence were applied to test for association among categorical variables. P-values less than 0.05 were considered significant. All analyses were performed using SPSS 13.0 for Windows (SPSS, Inc., Chicago, IL).

RESULTS

At least 19 of the 203 (9.36%) C-implants loosened during the IMF period. On the other hand, 16 of the 165 implants in men and 3 of the 38 implants in women failed. There was no significant difference in the failure rate between men and women (Table 2). Table 2 shows that 2 out of 42 implants failed in patients less than 20 years of age; 7 out of 69 implants failed among those aged 20~29 years, and 10 out of 82 implants failed in patients over 40 years of age. Moreover, there was no significant difference between patients with periodontitis and healthy periodontium. As shown in Table 3, there was no significant difference in failure rates due to placement sites. On the contrary, there was significant difference in failure rates for keratinized and non-keratinized gingiva (P=0.017). According to the radiographs, there was significant difference in failure rates due to root contact with implants (P=0.003).

DISCUSSION

We retrospectively investigated risk factors and complications related to the failure of a two-part titanium C-implant fixated on the alveolar bone. At least 19 out of a total of 203 implants failed (9.3%). The failure rate of C-implants used for orthodontic anchorage ranged from 13% to 25% in various studies[15-18]. Unlike orthodontic mini-implants, the mini-implants used for IMF were loaded laterally and subjected to orthognathic load of more than 1000g compared to 150~200g for orthodontic movement[14]. These excessive moments could have about the biological and mechanical failure of the implant. Note, however, that the relatively high success rates in our study seem to be attributable to the SLA treatment of the implant; moreover, the design was able to endure the shear force, and the treatment time was short. The multiple mini-implants may have also distributed the stress better.

Generally, the surgical procedure of C-implant is more complex than one-component mini-implants. The screw part is implanted first, and then the head part is inserted by mechanical friction. This type of mini-implant requires cortical penetration with a guide drill, which is not necessary for most one-component mini-implants. Note, however, that the excessive force of conventional self-drilling mini-implant during placement in the mandible can disrupt the contact between the mini-implant and the driver and alter the screws.

In this study, we used two-component C-implants selectively to achieve IMF in patients who had difficulty in using the one-component design. In some periodontal patients, the attached gingiva was unavailable for implantation; thus leaving us no choice but to use the non-keratinized tissue. Moreover, in cases wherein the distance between the placement site and incision line is too short during two-jaw surgery or one-jaw surgery with genioplasty, the mini-implant may be covered by soft tissue after suturing. The characteristics of the changeable head portion in a C-implant can help overcome these problems. Therefore, the 9.3% failure rate achieved in this study may not be very high considering the fact that the two-part C-implant needed to be applied instead of the one-component design[15-18].

There are many causes of mini-implant failure: abnormal position, adjacent tooth injury during implant placement, infection, overload, impingement of soft tissues, and technique of the operator[15-18]. Unlike previous studies[19, 20], our study showed no significant difference in failure rates according to age. Nonetheless, the lowest failure rates were noted in patients under 20 years, and the highest failure rates, in patients over 30 years. These results were assumed to be due to poor bone quality and oral hygiene in older patients[21]. There was no significant difference in failure rates according to the existence of chronic periodontitis in this study. The results did not coincide with the previous findings on dental implants with inflammation of peri-implant tissue, i.e., infection by microorganisms around implants can cause implant failure[22-24]. There was no difference according to the placement of the implant in the maxilla or mandible or whether it was near the canine, premolar, or first molar. Several authors found more failures in the maxilla than in the mandible[20,25-28]. However, higher failure tendency in the mandible from our research seems that it is difficult to place the implant perpendicular to the alveolar bone surface and the implant may become unstable by over-heating during guide drilling due to a thick cortical bone. Pilot drilling should be performed only at the level of the cortical bone. Drilling too deep can cause over-heating or root injuries. In our study, the same results were achieved with regard to the absence of keratinized mucosa around mini-implants, which significantly increased the risk of infection and implant failure as in the study of Adell, et al[29]. Cheng and Tseng also reported that implants in the posterior mandible were more susceptible to infection, mainly because less attached gingiva was available in this region[16].

When the implant is placed at the alveolar crest located on the attached gingiva, however, the risk of dental root damage may increase; the maintenance of the implant may also be difficult due to the insufficient supporting alveolar bone. Based on the periapical radiographs, 7 out of the 22 implants that had root contact failed. Only 12 out of 162 implants showing no root contact failed. Borah and Ashmead reported that titanium screws had no problems in the tooth in impinged state[30]. In addition, direct contact between implant and teeth did not create problems after implant removal[31].

Contact between the implant and the dental roots can occur, with serious complications. This study reported 1 case of fractured implant, 1 case of endodontic treatment due to pulpitis, and 1 case wherein the upper second premolar was extracted due to root fracture. The fracture was not caused by the screw but by deep pilot drilling, since the screw apex was too blunt. Moreover, the mini-implant apex was fractured because the operator implanted this mini-implant on the mandible using a 1.2mm guide drill that was too narrow for the size of the apex. Root fractures and/or pulpitis may have been caused not by the implant but by the guide drill. Careful placement of the implant was essential in preventing failure. One mini-implant between the right canine and first premolar proved to be difficult to remove 3 months after the IMF period. Therefore, we opened the flap under local anesthesia and removed using How pliers. Higher osseointegration and damage on the adapter part of the screw were assumed to have made removal difficult.

Pinpointing the precise causes of implant failure is difficult to in this study. The risk factors of the C-implant in IMF were dental root injuries and characteristics of soft tissues. Solving the implant failure during surgery and supra-structure failure in the middle of loading for IMF was not easy. A previous report claimed that the implant length had no effect on the success rate[1]. In our study, only the 9.5mm C-implant was used for IMF. Therefore, further study will be needed with regard to the success rate of the mini-implant using further reduced lengths.

CONCLUSION

The two-component design of the mini-implant has advantages such as the easy application of multiple elastics and high resistance to fracturing or deformation during placement and/or removal compared to the one-component mini-implant in various complex cases of IMF. Note, however, that the factors influencing implant failure included age, root damage, and characteristics of soft tissues.

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