Radiographic and Surgical Template for Placement of Orthodontic Microimplants in Interradicular Areas: A Technical Note

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Purpose: *In recent years, microimplants have gained popularity in orthodontics. Microimplants are primarily placed in complex sites where critical anatomic structures, such as roots of teeth, may be damaged, so precise surgical planning is required prior to placement. The goal of this report was to introduce a newly developed technique for the placement of microimplants in interradicular areas and evaluate its accuracy.* ***Materials and Methods:*** *The planned placement site is radiographed using a radiographic template and film holder fabricated by the investigators. The resultant radiograph is clipped and attached to the radiographic template to make a surgical template to guide the placement of the microimplant. Forty-one patients, 15 men and 26 women ranging in age from 21 to 29 years, were enrolled in this study. On 1 side of the arch, this novel technique was used for implant placement, and on the other side, an established method reported by Maino and associates (ie, the control technique) was used.* ***Results:*** *A total of 116 microimplants 2 mm wide and 9 mm long were placed interradicularly in 41 patients. Twelve of 58 microimplants were placed unsuccessfully in the control group, versus 2 of 58 in the test group. Statistical analysis showed that there was a significant difference between the 2 techniques in terms of success rate (P < .05).* ***Discussion:*** *Presurgical diagnosis of bone quantity and transfer of the information to the surgical sites are vital in microimplant placement. Radiographic templates modified for surgical purposes have the advantage of transferring radiographic information directly to the surgical site.* ***Conclusion:*** *This study, although limited in some respects, demonstrated that microimplant placement can be improved using the newly developed technique described.* INT J ORAL MAXILLOFAC IMPLANTS 2006;21:629–634

Key words: *anchorage, microimplants, orthodontics, surgical templates*

Anchorage control has been a key issue in orthodontics.[1] Methods of bone anchorage such as retromolar implants, on-plants, zygomatic wires, ankylosed teeth, palatal implants, miniplates, and mini-implants have made it possible to overcome previous limitations of orthodontic tooth movement. For example, it is now possible to move the entire dentition in the same direction or to correct an open bite with molar intrusion.[2] These procedures may eventually change the way orthodontic treatment is planned and carried out.

The microimplant is one such technique. It has gained wide use as an absolute anchor in orthodontics.[2–9] These inexpensive implants, which are small in diameter (1.2 to 2.0 mm) and come in several lengths, are placed primarily in the interradicular spaces of the posterior maxilla for absolute anchorage.[4,10,11] Because the microimplant depends almost entirely upon mechanical retention within the bone and requires a tight fit, it is recommended that the longest possible microimplants be used.[2] However, the possibility of jeopardizing the health of the adjacent tooth roots may increase as the size of microimplants increases. Microimplant failures can be attributed to several factors, among which damage to adjacent tooth roots may play an important role.[2] Furthermore, although microimplants can provide

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Fig 1 The acrylic resin bite block was flat and 5 mm thick. With 3 parallel orthodontic metal wires inserted, it served as a radiographic template.

stable anchorage, they may not remain absolutely stationary throughout orthodontic loading in cases of heavy load. To prevent microimplants from contacting dental roots because of displacement, it is recommended that a safety margin of 2 mm be allowed between the microimplant and the dental roots.[12] Precise presurgical planning is very important to avoid damaging dental roots and should include estimation of bone quantity and careful selection of diameter and length of the microimplant, placement site, and direction of placement.

To achieve precise placement of microimplants in interradicular sites, several methods have been developed. With the help of intraoral radiographs, Maino and associates used a surgical index fabricated from orthodontic wire and thermoplastic or acrylic resin to determine the point of screw placement.[7] However, this method, like those reported by Kyung and colleagues[2] and Bae and coworkers,[13] could not transfer information regarding the amount of space between the roots directly to the surgical sites.[2,13] The radiographic and surgical template used in the placement of bicortical miniscrews in the areas between dental roots invented by Freudenthaler and associates is effective but has the disadvantages of requiring computerized tomography (CT) and being more complicated to fabricate.[14]

An effective radiographic and surgical template for the placement of microimplants in interradicular regions without contacting the dental roots has been developed. The purpose of this article was to compare the clinical accuracy of this newly developed technique with that of the method reported by Maino and associates.[7] The null hypothesis was that the 2 techniques would not differ in accuracy when used for placement of microimplants in interradicular regions.

MATERIALS AND METHODS

Forty-one patients, 15 men and 26 women from 21 to 29 years old, were enrolled in the study. All of them had bimaxillary protrusion. After extraction of the 4 first premolars, microimplants were planned to provide absolute anchorage for retracting the anterior teeth. Placement of the implant sites between the roots of adjacent teeth was planned. Two surgical guidance techniques, the established method of Maino and colleagues[7] and the newly developed technique, were used for microimplant placement (1 on either side of the arch). All operations were performed by a single experienced surgeon.

Fabrication of a Radiographic Template

The template for the new technique is fabricated as follows. Complete-arch impressions and plaster casts are made when the patient is ready for microimplant placement in the interradicular region. A flat bite block 5 mm thick is fabricated using autopolymerizing acrylic resin on the teeth adjacent to the planned implant placement sites. The flat surface of the bite block is parallel to the occlusal plane. Three 0.018-inch stainless steel orthodontic wires are placed in the block parallel to each other and to the flat surface of bite block before the acrylic resin is polymerized. To determine the mesiodistal direction of the wires, the middle wire is superimposed over an imaginary line through the center of the interseptal bone of 2 adjacent teeth (Fig 1). The flat bite block with orthodontic wires then serves as a radiographic template. It is essential that the bite block be stable on the teeth and that it can be placed and removed easily.

Intraoral Radiograph Using the Long-Cone Parallel Technique

A simple film holder is fabricated to obtain intraoral radiographs. This instrument consists of film backing, a bite block, and an indicating part and is made of a transparent plastic (thermoplastic polyester; Raintree Essix, Metairie, LA) (Fig 2). It can align the x-ray source, teeth, and film in a straight line and guide the central x-ray perpendicular to the radiographic film. The indicating part is a horizontal outstretched section of the bite block. The straight side of the indicating part is perpendicular to the film backing (Fig 2). Several parallel lines on the bite block are also perpendicular to the film backing. With the radiographic template in position in the patient's mouth, the film holder is adjusted by superimposing 1 of the parallel lines on the bite block over 1 of the metal wires on the radiographic template. Figure 3 shows this positioning using a cast. A line on the x-ray cone (Oralix AC; Danaher/Gendex, Milan, Italy) indicates the central x-ray. By

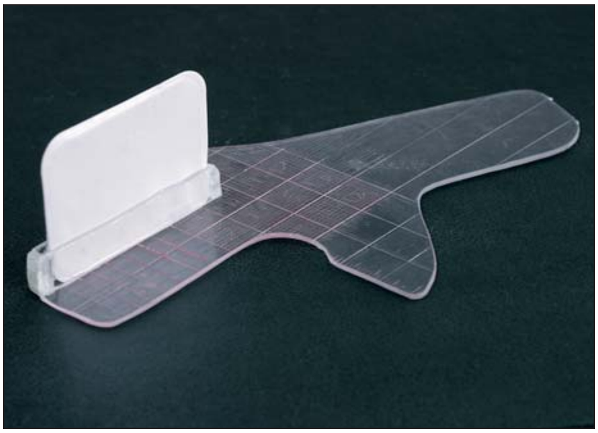

Fig 2 The film holder, which was fabricated by the investigators, consisted of the film backing, bite block, and indicating part. It was made of a transparent plastic. The straight side of the indicating part, which was perpendicular to the film backing, guided the projection of the x-ray beam. Several parallel lines were made on the bite block perpendicular to the film backing, which were used to ensure that the film holder was correctly positioned in the mouth.

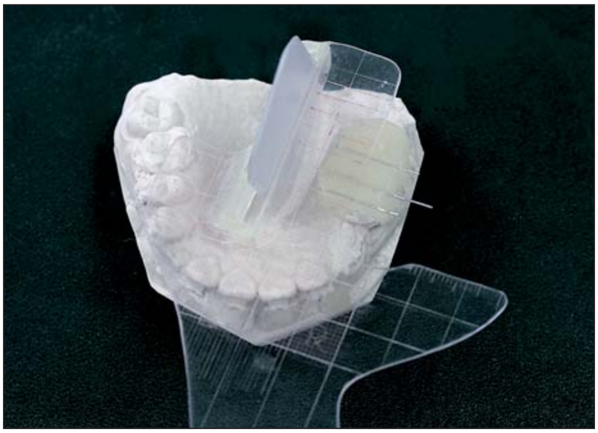

Fig 3 With the radiographic template in position, the film holder is adjusted so that 1 of the parallel lines is superimposed over 1 of the metal wires on the radiographic template.

aligning the straight side of the indicating part of the film holder so that it is parallel to the line on the x-ray cone, the projection of the x-ray can be planned (Fig 4). Size 2 dental film (E speed; Eastman Kodak, Rochester, NY) is used for exposure. Based on the resultant radiograph showing details of the teeth and the interradicular spaces, it is possible to determine whether a microimplant is suitable for the situation.

Fabrication of a Surgical Template

On the resultant radiograph, the images of the 3 metal orthodontic wires on the radiographic template appear as dots (Fig 5). The film is clipped along the edge of the roots of interest and trimmed to make it fit the movable soft tissues near the site of placement. The clipped film is then attached to the buccal side of the radiographic template with the 3 orthodontic wires perforating the 3 dots (Fig 6). The middle metal wire is bent occlusally at a 30- to 40-degree angle for the maxilla and at a 10- to 20-degree angle for the mandible, which was the angulation recommended by Kyung and colleagues[2] (Fig 7a). The radiographic template is then modified by attaching the clipped radiograph, which serves as a surgical template transferring the information of the interradicular region to the surgical site.

The template is placed in glutaraldehyde before surgery for disinfection. After disinfection of the mouth, the disinfected surgical template is seated on the teeth, and the patient bites down hard on it. For this study, placement of microimplants on the control side was carried out using the procedures described by Maino and associates.[7]

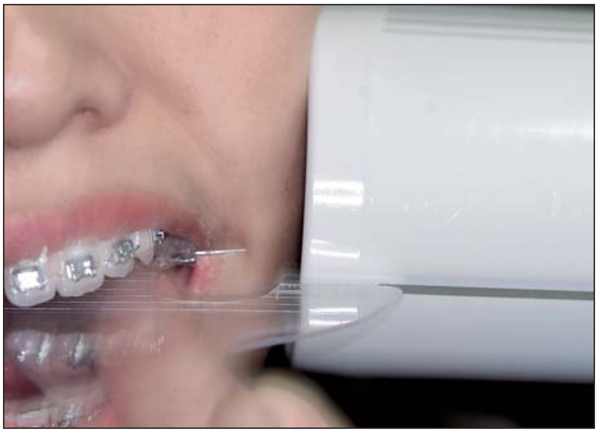

Fig 4 The line on the x-ray cone and the straight side of the indicating part of the film holder are kept in the same direction during film exposure.

On the test side, implants of a suitable diameter and length for the planned interradicular placement sites were selected. After determining the appropriate drilling site and selecting the appropriate drill, drilling commenced at a speed of 400 rpm with water as a coolant. During placement of the microimplants, the drill and screwdriver were kept in the direction of the bent middle metal wire, which served as a surgical guide (Fig 7b).

When drilling into dense bone, careful up-and-down strokes were used to minimize the heat generated by the low-speed handpiece. Excessive force should not be used with the drill. Any serious resistance after passing through the cortical plate is probably due to root contact, which means that the

Fig 5 On the resultant radiograph the three dots represent the images of three metal orthodontic wires on the radiographic template.

Fig 6 The film is clipped along the edge of the roots of interest and then attached to the buccal side of the radiographic template (process shown here with cast).

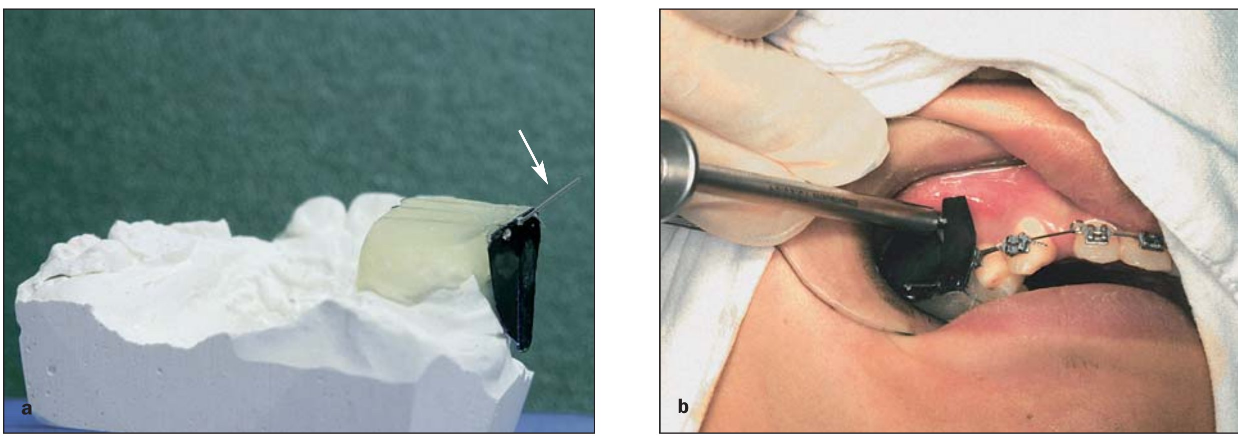

Fig 7 *(a)* The middle metal wire *(arrow)* is bent occlusally at a 30- to 40-degree angle for the maxilla and at a 10- to 20-degree angle for the mandible. *(b)* The screwdriver is applied in the direction of the bent metal wire, which serves as a guide. The cast shown was not made from the patient shown.

Table 1 The Outcome of Microimplants Placed with the 2 Techniques

	No. of implants that failed	No. of implants that succeeded	Total
Test technique	2	56	58
Control technique	12	46	58
Total	14	102	116

drill should be reinserted at a different angle. A manual screwdriver should be used so that the clinician can feel any resistance from roots and make adjustments to avoid them. Reinsertion of the drill or microimplant was regarded as unsuccessful placement. After placement, the position of the microimplant was examined by CT. Possible contact between the roots and the implant observed in the CT scans was also regarded as failure.

The success rate of microimplant placement was determined for each group, and the χ^2 test was used to compare the outcome with the new technique with the outcome achieved with the method established by Maino and associates.[7] $P < .05$ was considered statistically significant.

RESULTS

A total of 116 microimplants, 2 mm in diameter and 9 mm long, were placed interradicularly in 41 patients. Fifty-eight were placed with the control method and 58 with the test method. Sixty-eight implants were placed between the roots of the maxillary second premolar and first molar, 28 were placed between the roots of the mandibular second premolar and first molar (either side), 16 were placed between the roots of the maxillary first and second molars (either side),

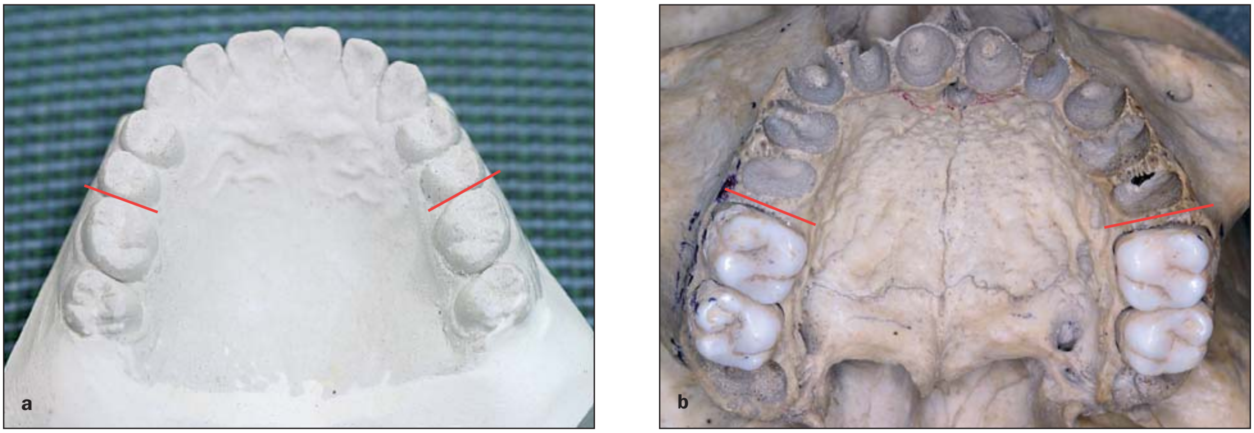

Fig 8 Imaginary line running through the center of the interseptal bone are shown in *(a)* a cast and *(b)* a dry adult human skull.

and 4 were placed between the roots of the mandibular first and second molars (either side).

Table 1 shows the outcomes of microimplants placed with the 2 techniques. A significant difference was found between the success rates of the 2 techniques ($P < .05$).

DISCUSSION

Presurgical diagnosis of bone quantity and transfer of the information to the surgical sites are vital in microimplant placement. The use of CT provides practitioners with the ability to assess bone quantity and quality and critical anatomic structures before surgery.[14] Advanced radiographic techniques allow better bone evaluation; however, orientation to a specific implant site is difficult, and extra CT scanning adds more radiologic exposure and makes the procedure more expensive.[14–16] Simple periapical or bitewing radiography using the long-cone parallel technique provides images of the teeth with minimal distortion and is a common method for the diagnosis of bone quantity available for microimplant placement in the alveolar bone.[17] However, it has an unfortunate limitation for this application: The amount of space between the roots shown on the resultant film is often influenced by the projection angle of the x-ray beam.

Orientation of the wires inserted in the radiographic template is very important, since these wires will determine the direction and angulation of the central ray during film exposure. To determine the horizontal direction of the wires, the middle wire was placed first, superimposed on an imaginary line running through the center of the interseptal bone of the adjacent teeth. Figs 8a and 8b show this imaginary line on both a cast and a dry adult human skull. If the x-ray beam is parallel to the imaginary line during film exposure, the image of the space on the resultant film shows the largest amount of space available for placement of a microimplant. If the x-ray beam is not parallel to the line, the image of the space available will appear smaller than it actually is because of the overlapping images of the adjacent teeth.

A specially designed film holder was used to align the teeth, the film, and the source of the x-ray during film exposure. Lines were etched on the bite block of the film holder for the purpose of aligning the film holder with the radiographic template and thus with the x-ray beam. By aligning the straight side of the indicating part of the film holder parallel to the line on the x-ray cone, the wires and the x-ray were aligned in the same direction. On the resultant radiograph, the image of the metal wires are dots, not lines. If the film holder is not placed on the radiographic template correctly, the x-ray beam will deviate from the direction of the wires, and the wires will appear as lines rather than dots on the radiograph. Correct placement of the film holder on the radiographic template allows for correct guidance of the drill.

Transferring radiographic information to the surgical site is a difficult task. The intraoral radiograph obtained using the new method showed roots and the amount of space between the 2 adjacent teeth without any distortion, thus allowing the orthodontist and surgeon to evaluate the safety of placement of a microimplant near the roots and to determine the optimum implant size and site of placement. The authors hypothesized that, since the image of the teeth on the resultant intraoral radiograph is like the perpendicular projection of teeth on the film parallel to the long axis of the teeth, if the film were moved bodily along the direction of the x-ray and attached to the buccal side of the teeth, the image of the teeth on the attached film would be like the projection of the teeth on the buccal side of the alveolus. The shape of the roots and amount of space between the teeth could then be seen directly on the buccal side. When the film is clipped along the edge of the roots and perpendicularly attached to the radiographic template, the surgeon is able to "see" the dental roots.

Radiographic templates modified for surgical purposes have the advantage of transferring radiographic information to the surgical site.[18–22] Use of the new surgical template was simple and eliminated worry about the possibility of damaging the adjacent dental roots.

The established technique reported by Maino and colleagues[7] was selected as a control method because the acrylic resin used in the technique can easily be adapted, and it allows the surgeon to decide the site of placement based on the image of the metal markers placed on the acrylic resin. Twelve of 58 microimplants were unsuccessful in the control group versus 2 of 58 in the test group. Significant difference was seen between the 2 groups, which indicates that the newly developed template allows for more precise placement of microimplants in interradicular areas. The failure rate of the established method was higher than that of the new method, partially because the acrylic resin used in the established method cannot indicate the direction of drill and screwdriver during the placement of microimplants.

The surgical template reported herein facilitates precise placement of orthodontic microimplants but, as any other technique, it has its limitations. Fabrication of the radiographic template is time consuming, and the technician must be meticulous in placing the metal wire into the radiographic template, because the metal wire shows the direction of the x-ray beam, which is important in analysis of bone quantity in the interradicular region. Although the bent metal wire on the newly developed template can indicate the direction of the drill and screwdriver, the operator still needs to be vigilant about keeping the drill and screwdriver in the direction of the bent wire during operation.

In conclusion, this surgical template can assist the surgeon in determining the amount of bone available for microimplant placement between the roots and the direction in which to drill. It can be used successfully to place orthodontic microimplants in the correct position. Further research is needed to develop a simpler template based on the same principles.

ACKNOWLEDGMENTS

This study was partly funded by grants from the Health Bureau of Zhejiang Province (no. 491060-I20502) and the Education Bureau of Zhejiang Province (no. 20040230).

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