A Three-Dimensional Radiographic-Surgical Guide for Mini-Implant Placement

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The latest titanium miniscrews are small enough that even anatomical regions with minimal bone quantity can be used as implant sites for skeletal anchorage.[1-16] The interradicular septum is one of the most commonly used locations when a complete dentition is present,[11,12,16-19] but the risk of damage to adjacent dental roots and the maxillary sinus must always be considered.[3,7,12,15-18,20-22]

Several authors have developed surgical guides that are recorded on radiographs.[1,3,11,16,18,20,23] The two-dimensional radiographic image of such a guide does not necessarily reflect its true spatial relationship with adjacent anatomical structures, however; variances between focal point and object and imperfections in the film can cause an oblique projection and, thus, a distorted image.[20,24-27] This, in turn, can lead to inaccuracy in the penetration angle of the pilot drill.[21,28]

The present article describes a three-dimensional radiographic-surgical guide that ensures an exact correspondence between the x-ray and drill trajectories.

Design Principles

The Radiographic-Surgical Guide (RSG) is an .045" stainless steel telescopic tube soldered to the end of a vertical arm, which is attached to a horizontal arm by a Gurin lock (Fig. 1A). Both arms are made of .021" × .025" stainless steel wire, allowing the RSG to be inserted into the fixed orthodontic appliance (Fig. 1B).

The Modified Radiographic Positioner (MRP) is a bitewing positioner with a securely attached


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.040" stainless steel wire (Fig. 1C). The free end of this wire, perpendicular to the film plane, is inserted into the telescopic tube of the RSG (Fig. 1D).

As a radiographic guide, the RSG positions the MRP, which defines the x-ray path (Fig. 2A). If the presurgical radiograph shows the telescopic tube in a safe relationship to the interradicular septum and adjacent roots, the RSG can also be used as a guide for the pilot drill (Fig. 2B). The tube should be long enough to allow the drill to pene-

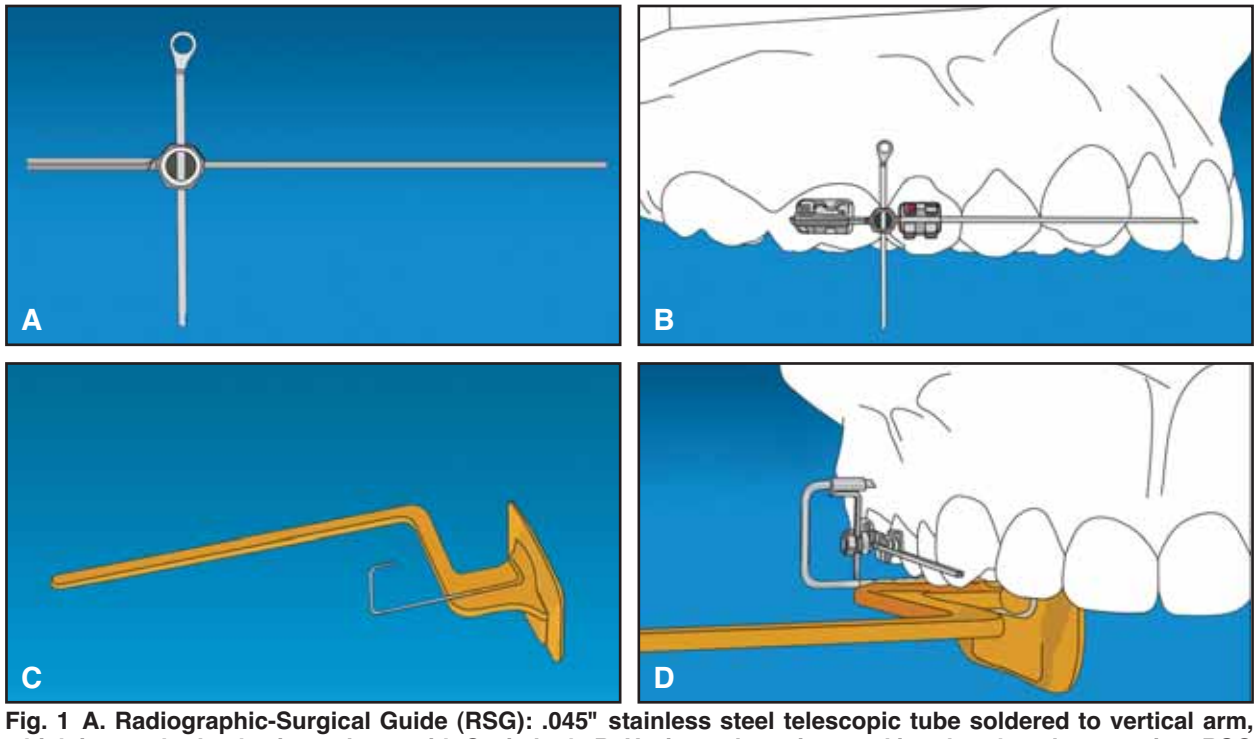

Fig. 1 A. Radiographic-Surgical Guide (RSG): .045" stainless steel telescopic tube soldered to vertical arm, which is attached to horizontal arm with Gurin lock. B. Horizontal arm inserted into bracket slots to orient RSG during radiographic and surgical procedures. C. Modified Radiographic Positioner (MRP) with attached .040" stainless steel wire. D. MRP wire inserted into telescopic tube of RSG for bitewing x-ray.

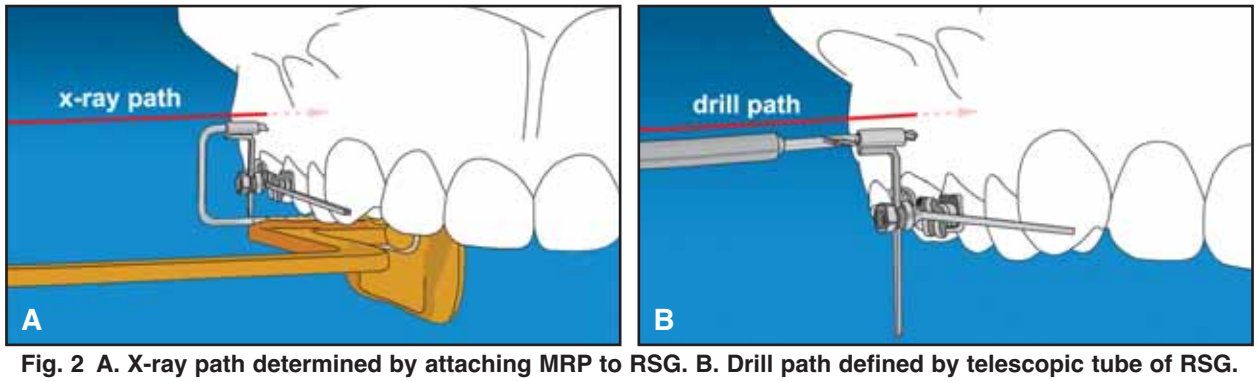

Fig. 2 A. X-ray path determined by attaching MRP to RSG. B. Drill path defined by telescopic tube of RSG.

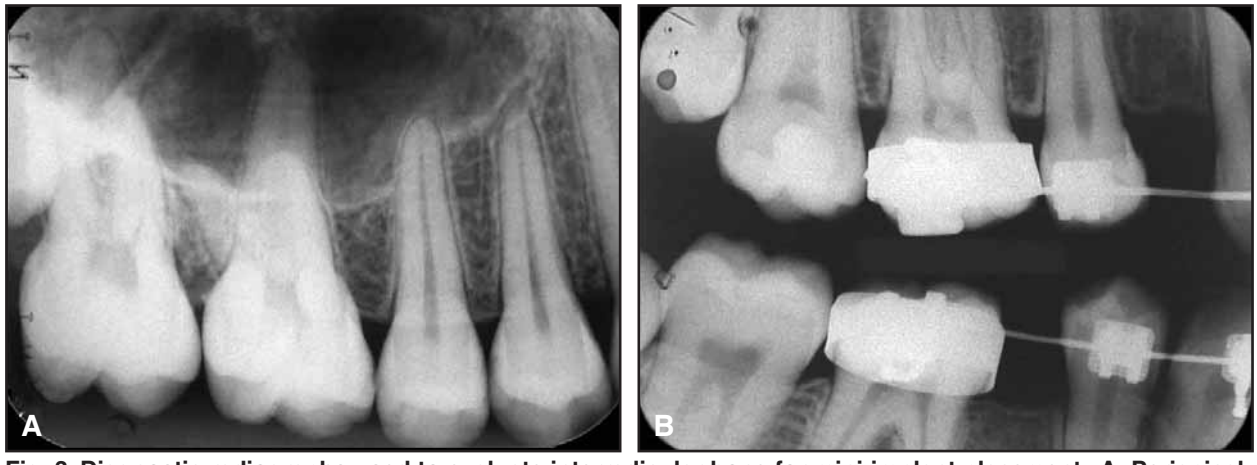

Fig. 3 Diagnostic radiographs used to evaluate interradicular bone for mini-implant placement. A. Periapical. B. Bitewing.

trate the mucosa and bone tissue of the interradicular septum to a depth corresponding to the selected mini-implant length.[18]

Clinical Procedure

Whenever mini-implant anchorage is indicated, the desired implant site should be evaluated with a bitewing or periapical x-ray[1,15,16,18-21] (Figs. 3,4A). If the interradicular septum is to be used for the implant, it should be at least 2.5-3mm wide, because the miniscrew will take up about half this space.[16,17,29] The mini-implant placement procedure is as follows:

The RSG should be autoclaved in advance, and the MRP sterilized with 2% glutaraldehyde for 10 hours.[30] At the surgical appointment, the patient's teeth are prophied, followed by a 12% chlorhexidine mouthrinse to reduce the risk of contamination during surgery.

The RSG is attached to the fixed appliance by inserting the .021" × .025" horizontal arm into the .022" × .028" bracket slots (Fig. 4B,C). The vertical arm should be adjusted by sliding it through the Gurin lock, so that the telescopic tube is centered on the interradicular septum, between the roots. The tube position can also be adjusted by torquing the vertical and horizontal arms or by placing slight bends in the vertical arm, although these modifications require more chairtime.

Next, the MRP is inserted into the telescopic tube, and a radiograph is taken to evaluate the relationship of the RSG to the adjacent roots (Fig. 4D). If there are no image superimpositions between the RSG and any anatomical structures, the drill angle will be safe. On the other hand, if a superimposition of the RSG indicates that damage could occur to the roots or maxillary sinus (Fig. 4E), the RSG should be repositioned, using the first radiographic image as a guide. Another radiograph should then be taken to ensure that the repositioning was correct (Fig. 4E').

Under local anesthesia, a 1mm (.040") pilot drill is inserted through the telescopic tube, using a slow speed of about 800rpm[20] and continuous normal saline irrigation (Fig. 4F). The Gurin lock is then unscrewed and the telescopic tube removed, allowing insertion of the mini-implant (Fig. 4G). Finally, with the RSG still in place, the MRP is reattached, and a final radiograph is taken to confirm the proper miniscrew position in the interradicular septum (Fig. 4H).

Discussion

The most common causes of root damage from mini-implant insertion are improper site selection and an inaccurate angle of drill penetra-

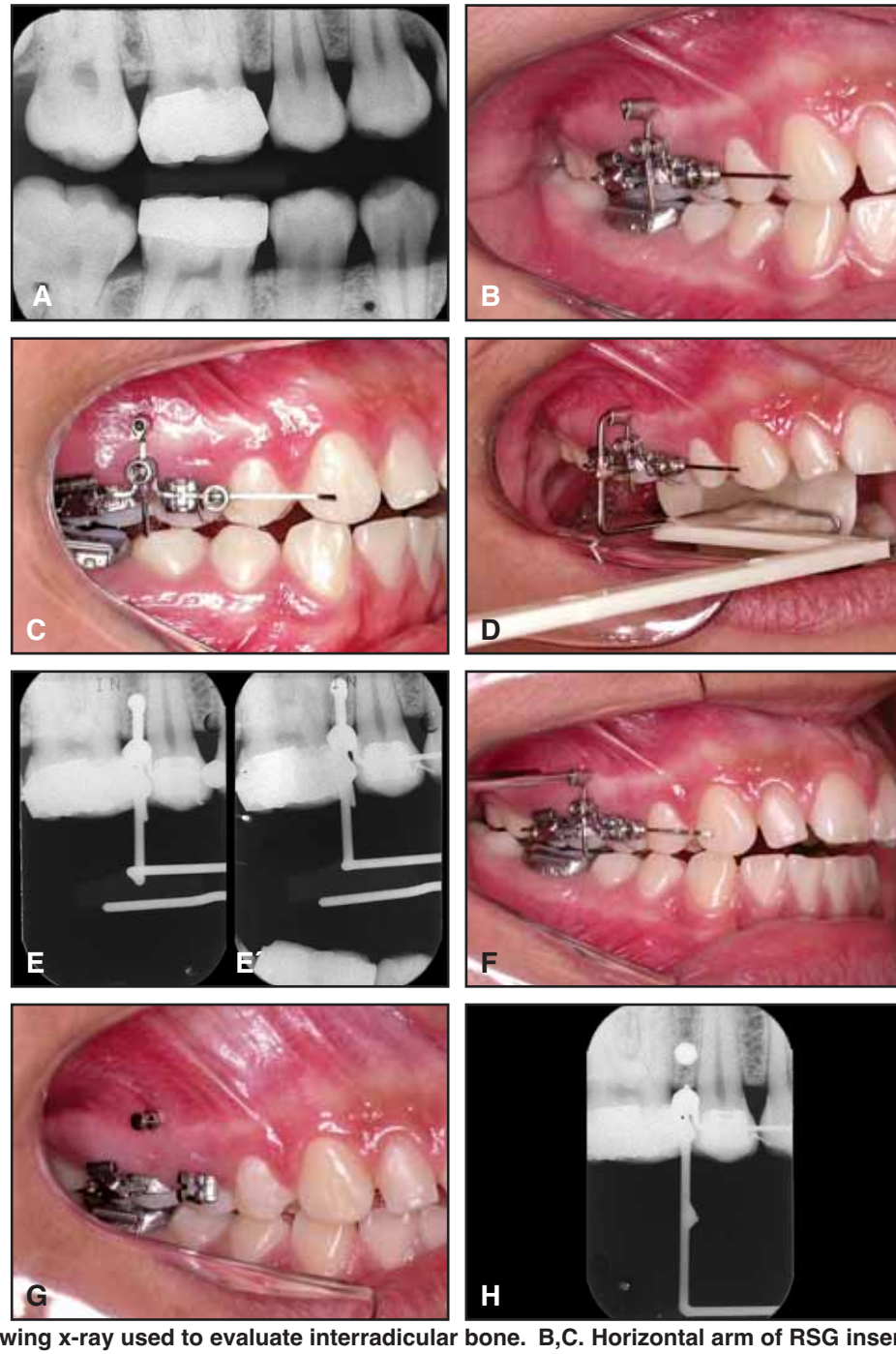

Fig. 4 A. Bitewing x-ray used to evaluate interradicular bone. B,C. Horizontal arm of RSG inserted into bracket slots. D. Radiograph taken with MRP attached to RSG. E. Initial radiograph shows contact with adjacent root. E´. After repositioning of RSG, subsequent radiograph shows proper placement in interradicular septum. F. Pilot drill inserted on path determined by RSG. G. Mini-implant screwed into place. H. Radiographic confirmation of final mini-implant position.

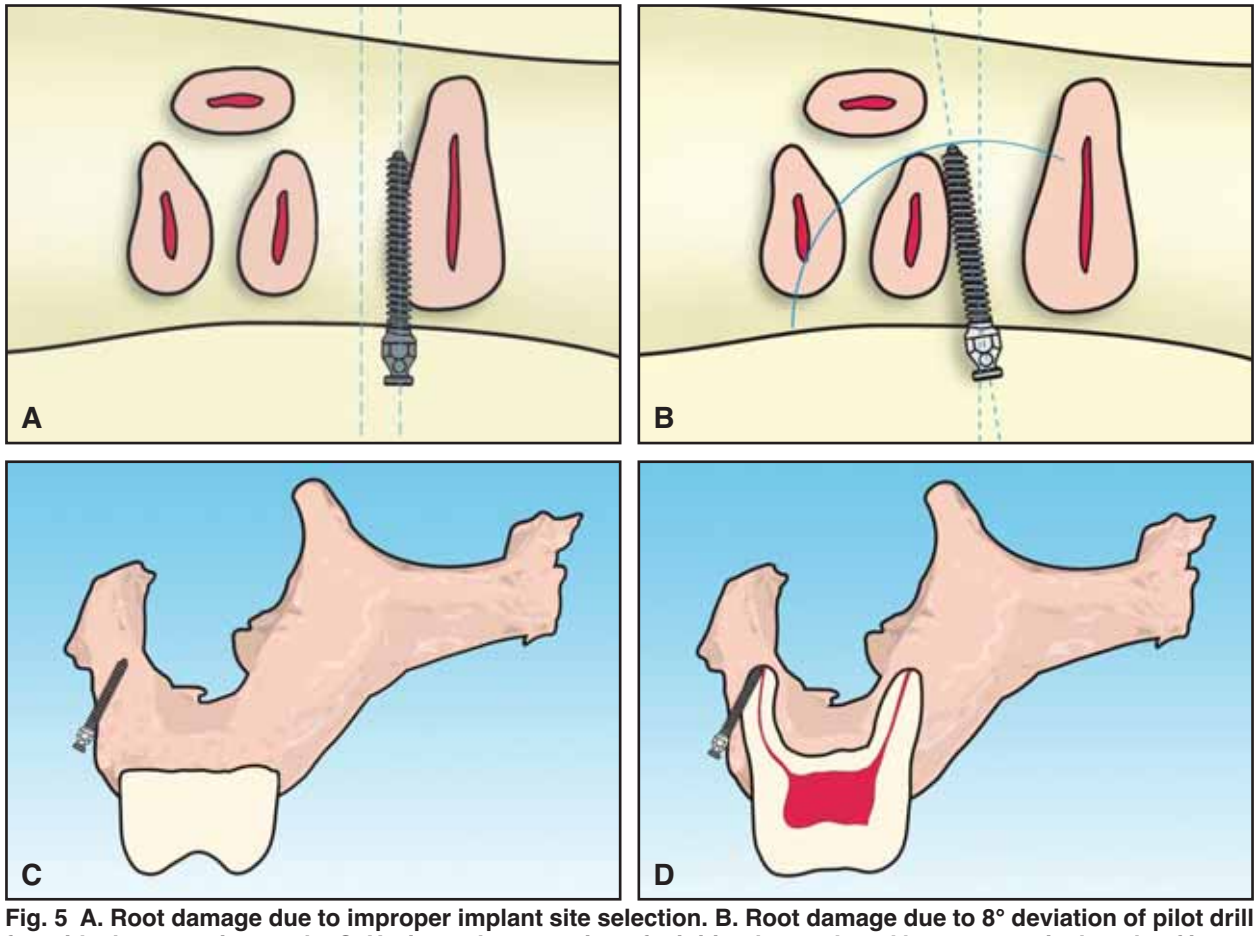

Fig. 5 A. Root damage due to improper implant site selection. B. Root damage due to 8° deviation of pilot drill from ideal penetration angle. C. Horizontal penetration of mini-implant reduced by more vertical angle of insertion. D. Root damage due to improper implant site selection, even with vertical angle of insertion.

tion (Fig. 5A,B). For every degree of variation from the ideal penetration angle, at a depth of 8mm, the tip of the surgical drill will deviate about .13mm. In other words, if the drill penetration angle is only 8° from ideal, the tip will deviate about 1.04mm (Fig. 5B). In the narrow interradicular septum,[31] even a minor error can result in root damage. Exposure of root dentin can cause inflammation and root resorption,[32,33] which can be exacerbated by orthodontic tooth movement.[20,34-36]

According to Mah and Bergstrand, mini-implants should be placed at an angle of no more than 10° from perpendicular to the bone surface.[20] More extreme vertical angulations, such as the 60° recommended by Park,[12] cannot be achieved with the technique described above. A more vertical angle of insertion will reduce the horizontal penetration depth of the mini-implant into the bone[9,12,31] (Fig. 5C), but that reduction is not enough to avoid root damage if the pilot drill is mistakenly inserted into the buccal alveolar plate, where the bone is extremely thin,[37,38] instead of the interradicular septum (Fig. 5D). Vertical angulation also places the drill closer to the maxillary sinus,[11,17,22] which may be critical if the radiograph shows a close proximity between the root apex and

the sinus.[38] Although some authors have speculated that a more vertical angulation would result in better miniscrew retention,[18] the long-term stability of such implants has not been evaluated.

Several other three-dimensional surgical guides for mini-implant placement have been developed. The techniques of Freudenthaler and colleagues[28] and Kitai and colleagues[22] require computed tomography, which entails a relatively high cost and increased radiation exposure.[18,39-43] Morea and colleagues do not evaluate the position of their guide in relation to the adjacent roots on a follow-up radiograph.[21] The surgical guide of Suzuki and Buranastidporn[44] is the most similar to the one described in this article, but their lack of a radiographic guide prevents standardization of the focal point, object, and film position. Furthermore, these authors use a telescopic tube with an internal diameter of 3mm for a 1.5mm pilot drill, allowing a drill deviation of as much as 16°. Even though their telescopic tube is used to guide the screwdriver for mini-implant insertion, the screwdriver and mini-implant are not rigidly attached. Forcing or self-drilling the miniscrew can lead to metal fatigue and eventual screw fracture.[18,45]

In our experience, the orthodontist can insert a mini-implant as accurately as an oral surgeon if the RSG is used. In fact, studies have shown that without the aid of a surgical guide, root damage can occur even when a miniscrew is placed by an oral surgeon.[46,47]

A bitewing is preferable to a periapical radiograph for evaluation of the interradicular septum, because the periapical exposure produces more obliquely projected and distorted images.[24,26,48] If the bitewing does not allow adequate visualization of the interradicular septum height, however, a periapical x-ray may be used. Taking the pretreatment radiograph with the RSG in place will save the patient one radiation exposure. If an additional radiograph must be taken during RSG positioning, the minor increase in radiation dosage will be justified to avoid the risk of root damage.[43,49-53] In any event, a final radiograph must be taken after implant placement to confirm the integrity of the adjacent roots.[3,7,11,12,21]

Conclusion

The use of the RSG to orient both the radiographic and surgical procedures ensures a coincident path for the x-ray and drill, minimizing the risk of damage to anatomical structures. A systematic study is currently being conducted to evaluate the precision of the RSG and MRP in predicting the correct positioning of mini-implants.

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