OVERVIEW

Development of Orthodontic Micro-Implants for Intraoral Anchorage

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(Editor's Note: In this regular column, JCO provides a summary of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.)

Successful orthodontic treatment has always required intraoral anchorage with a high resistance to displacement. Extraoral traction can be an effective reinforcement, but demands exceptional patient cooperation. The size, bulk, cost, and invasiveness of prosthetic osseointegrated implants have limited their orthodontic application.[1] Conventional bone screws can be used with bone plates to provide intraoral anchorage,[2] but the screw heads fail to protect the gingiva from the impingement of ligatures or attached elastics and make it difficult to attach coil springs and other orthodontic forces (Fig. 1).

We have developed a narrow titanium micro-implant, the Absoanchor,* that has a button-shaped head with a hole for ligatures and elastomers. Its small diameter allows its insertion into many areas of the maxilla and mandible that were previously unavailable, such as between the roots of adjacent teeth (Fig. 2).

Micro-Implant Selection

In general, an orthodontic micro-implant should be slightly longer and wider than the previously available surgical screws. This helps

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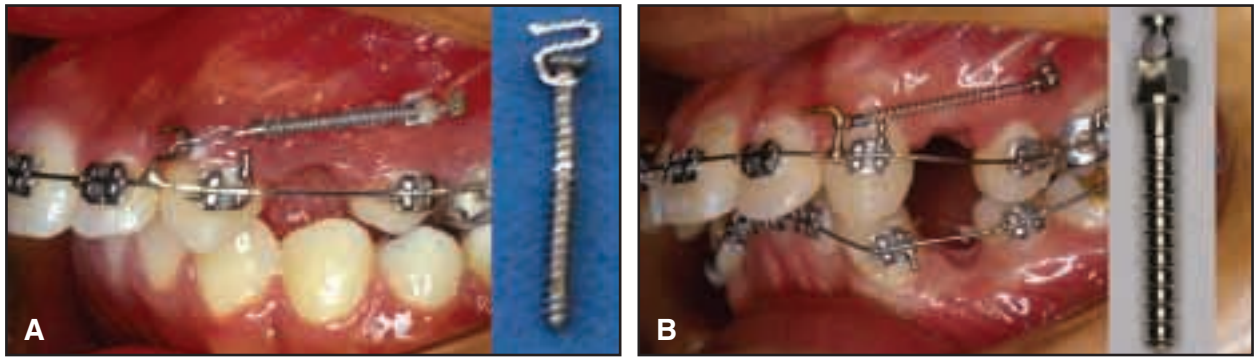

Fig. 1 Comparison of microscrews with attached nickel titanium closed-coil springs. A. Typical surgical microscrew. B. New orthodontic micro-implant (Absoanchor).

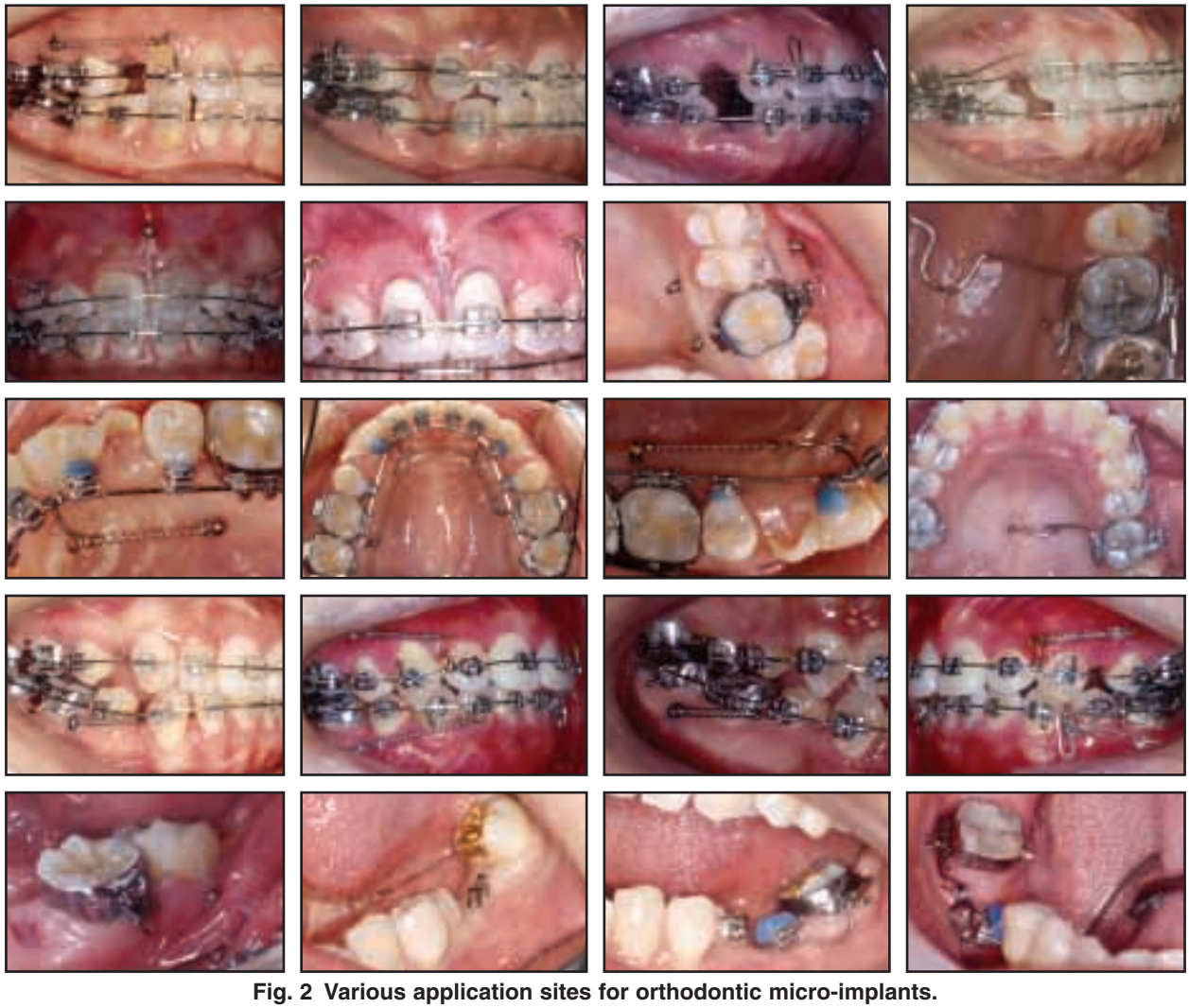

Fig. 2 Various application sites for orthodontic micro-implants.

compensate for the generation of larger moments by the orthodontic micro-implant head (Fig. 3).

The Absoanchor comes in diameters from 1.2mm to 1.6mm for different tasks and sites. Even the smaller 1.2mm and 1.3mm micro-implants can withstand as much as 450g of force, whereas most orthodontic applications need forces of less than 300g. The tapered type of micro-implant offers a tighter initial fit than the cylindrical type does (Fig. 4), making the first choice for orthodontic use a 1.2mm or 1.3mm tapered micro-implant. The next larger size should be tried until there is a close fit between screw and bone. A 1.4-1.6mm micro-implant can be used when there is enough space between the roots and greater force is needed.

Serial periapical x-rays should be used to determine whether adequate space exists for implant placement (Fig. 5). Computed tomography allows a more precise evaluation, but raises the issues of radiation exposure and expense. If enough space is not available, the clinician can consider moving the roots apart orthodontically before placing implants.

The rule of thumb is to use the longest micro-implant possible without jeopardizing the health of the adjacent tissues. The required length of the micro-implant is best judged during pilot drilling. In the mandible, the buccal surfaces and retromolar areas offer adequate thickness and quality of cortical bone for placement of 1.2-1.3mm-diameter micro-implants 4-5mm in length (Fig. 2). If lingual micro-implants are needed, the tori are suitable implant sites.

The cortical surfaces of the maxillary buccal area are thinner and less compact than those of the mandible and require longer micro-implants—generally 6-8mm for a 1.2-1.3mm diameter. The best sites for en masse retraction are the interdental spaces between the second premolars and first molars. Other good maxillary implant sites are below the anterior nasal spine

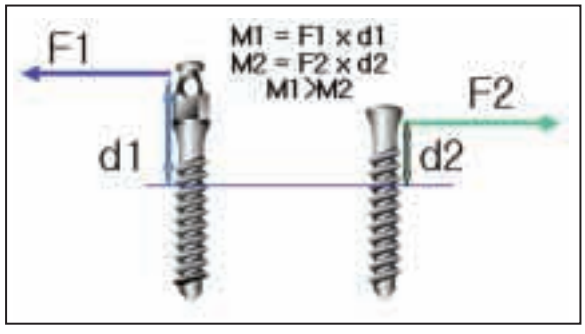

Fig. 3 Equal forces generate greater moment with orthodontic micro-implant than with conventional surgical microscrew.

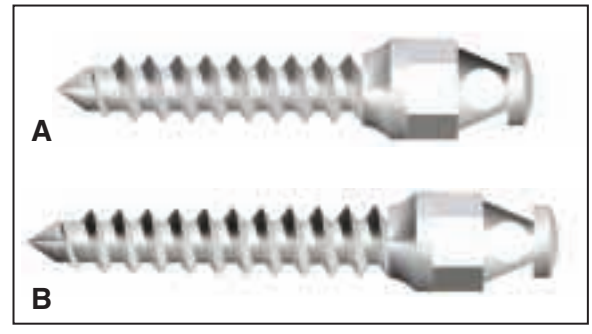

Fig. 4 A. Cylindrical Absoanchor. B. Tapered Absoanchor.

Fig. 5 Root approximation by micro-implant evaluated with periapical radiographs (A) or CT scan (B).

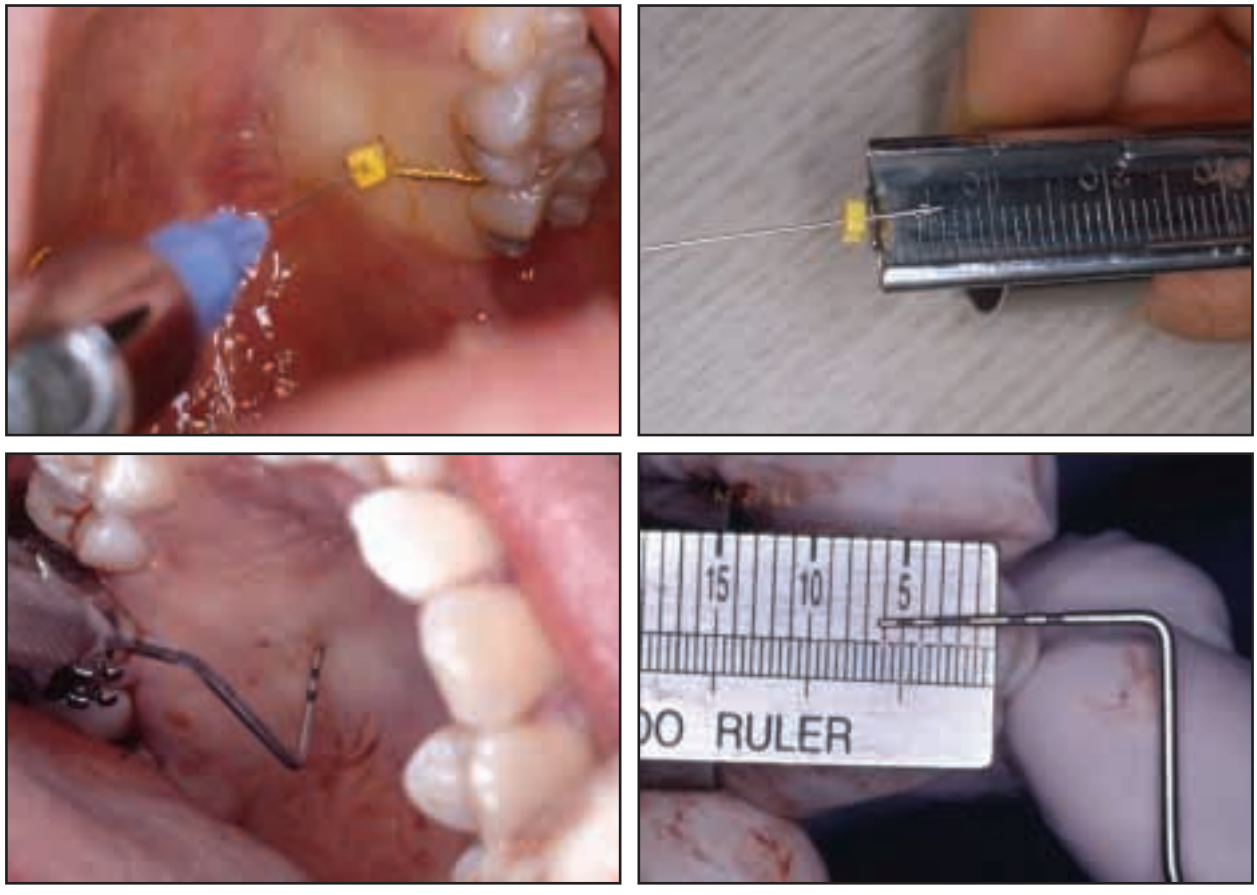

Fig. 6 Palatal mucosa varies greatly in thickness, requiring measurement during or after local anesthesia to select length of micro-implant.

(Fig. 2).

For a palatal implant, the mucosal thickness should be measured with an anesthetic needle or probe (Fig. 6). At least 6mm of the micro-implant should penetrate into the bone, which usually requires a length of 10-12mm for 1.2-1.3mm-diameter micro-implants placed in the interdental spaces. The midline areas contain high-quality cortical bone, but also osseous sutures, so that a micro-implant placed in the suture area should be a little thicker than usual. If the bony resistance of the suture area is inadequate, the micro-implant can be placed adjacent to the suture (Fig. 2).

Placement Procedure

A small amount of local anesthetic is sufficient for the simple surgical procedure needed to insert the Absoanchor. The clinician should not try to achieve profound anesthesia of the teeth, but only of the soft tissue. The teeth will be affected only if the bone drill approaches their roots, in which case the drill can be redirected away. When anesthetizing the palatal mucosa, the needle can probe and measure the mucosal thickness and help determine the screw length necessary for anchorage (Fig. 6). In extraction cases, Absoanchors can be placed after anesthetizing the teeth for removal, thus avoiding a second surgical procedure.

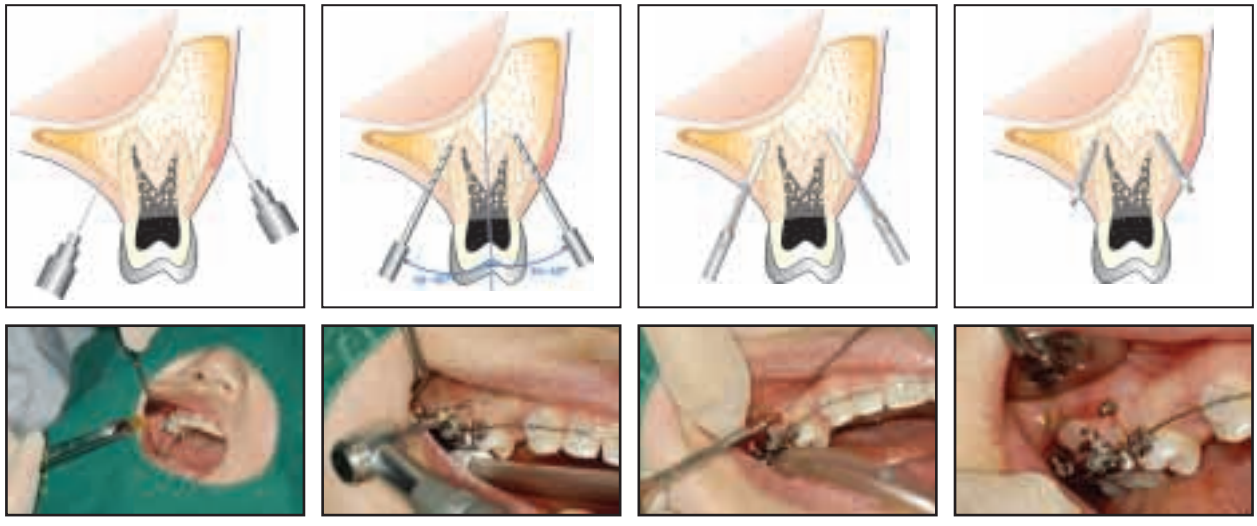

Fig. 7 Maxillary micro-implants placed through attached gingiva.

The implant sites should be marked with brass wires before drilling (Figs. 6,7). Maxillary micro-implant sites need a 30-40° angulation to the long axes of the teeth, either buccally or lingually, to increase the surface contact between the microscrew and the bone (Fig. 7). This will improve retention while reducing the risk of striking a root. The thicker mandibular cortical bone generally requires only 10-20° of angulation (Fig. 8). Cortical bone densities will vary from patient to patient, however, and from side to side in the same patient. When placing micro-implants in the palate, the greater palatine artery and nerve must always be avoided (Fig. 9).

If the micro-implant is inserted through movable soft tissue rather than attached gingiva, it is often preferable to use a screw without a button head, placing it completely beneath the gingiva with an emerging ligature wire hook for elastic attachment (Fig. 10). This reduces the risk of inflammation and infection.

The micro-implant depends almost entirely upon mechanical retention within the bone and thus requires a tight fit. The drill should be checked before surgery to make sure it has no bends that might cause it to wobble and inadvertently enlarge the opening. A low-speed contra-angle with a drill .2-.3mm narrower than the microscrew is normally used for the initial entry into the bone. The micro-implant itself should not be used for self-drilling, because this can lead to metal fatigue and eventual screw fracture. When using a microscrew narrower than 1.6mm in diameter, the drill should be extended the full length of the screw.

The drill can penetrate the mucosa, attached gingiva, and underlying bone without a surgical flap, but when entering through movable soft tissue, a small (5mm) retractable flap will prevent the soft tissue from rolling up around the drill (Fig. 10). A slow drill speed (400-500rpm) should be used with water irrigation to keep the surgical site lubricated. Faster drill speeds of as much as 30,000rpm will work, but run the risk of generating too much heat and thus causing osseous necrosis.

When drilling into dense bone, use careful up-and-down strokes to minimize the heat generated by the low-speed handpiece. Do not use excessive force with the drill. Any serious resistance after passing through the cortical plate is probably due to root contact, which means the drill should be reinserted at a different angle.

An engine-driven screwdriver in a low-speed contra-angle can be used for placing micro-implants, as in prosthetic dentistry. It is

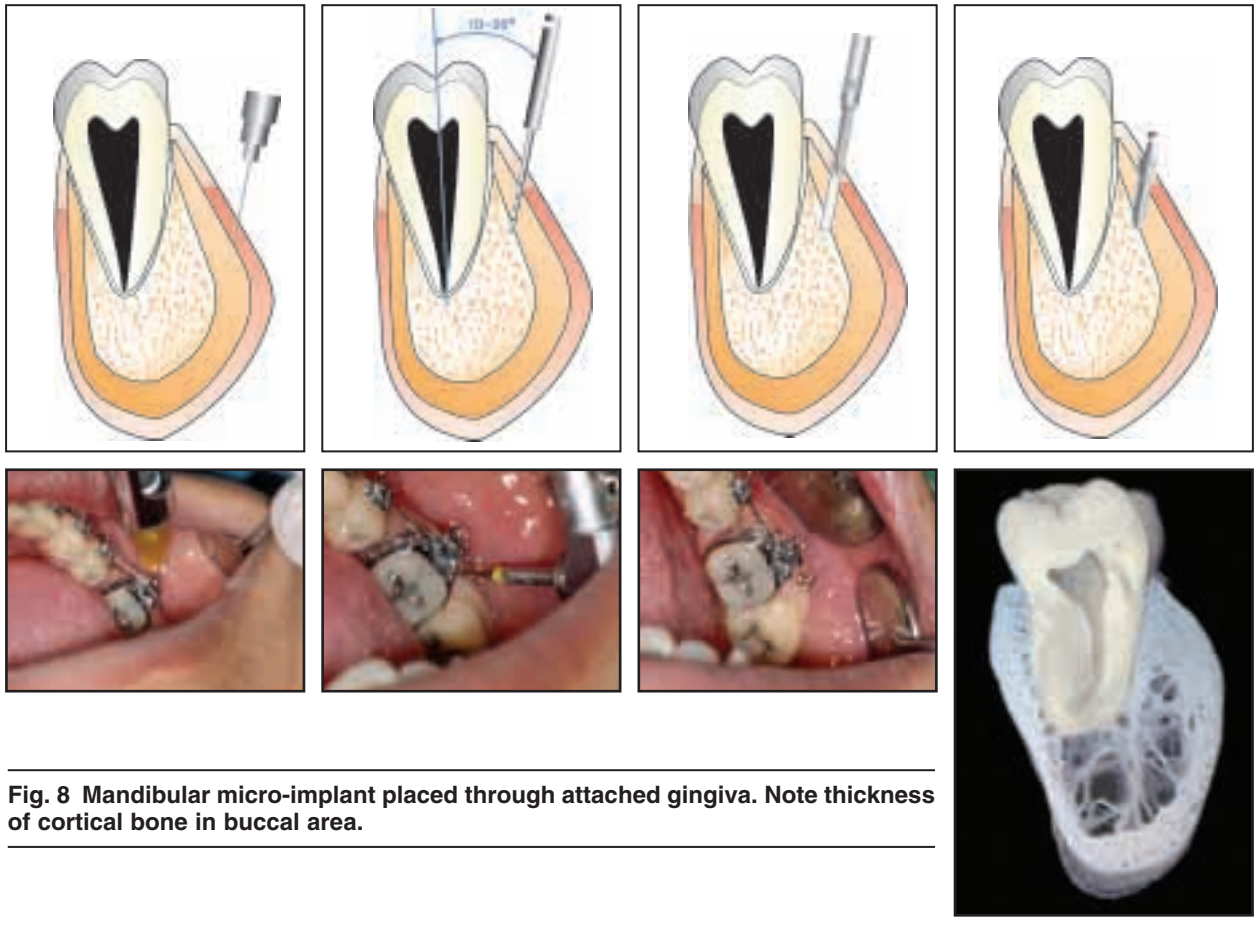

Fig. 8 Mandibular micro-implant placed through attached gingiva. Note thickness of cortical bone in buccal area.

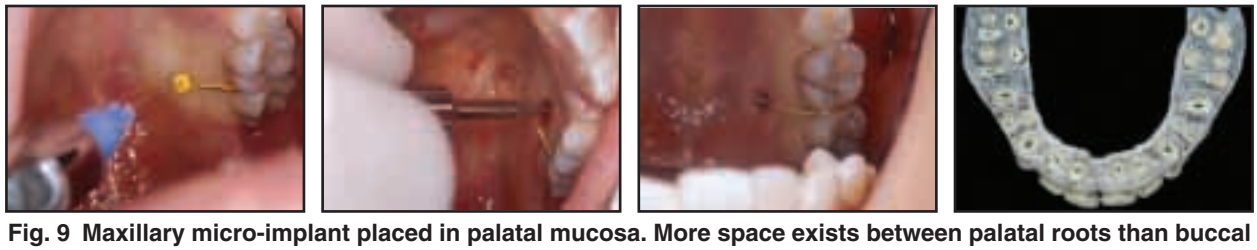

Fig. 9 Maxillary micro-implant placed in palatal mucosa. More space exists between palatal roots than buccal roots.

safer to use a manual screwdriver, however, so the clinician can feel any resistance from roots and make adjustments to avoid them. The long screwdriver is designed for buccal surfaces, and the short screwdriver for the palate (Fig. 11). Whenever resistance is encountered, withdraw the implant and redrill the bone with the pilot drill before reinserting the micro-implant.

If the fit of the micro-implant is not tight enough, replace the implant with the next larger size. Occasionally, a new site adjacent to the original one may need to be prepared. Once the

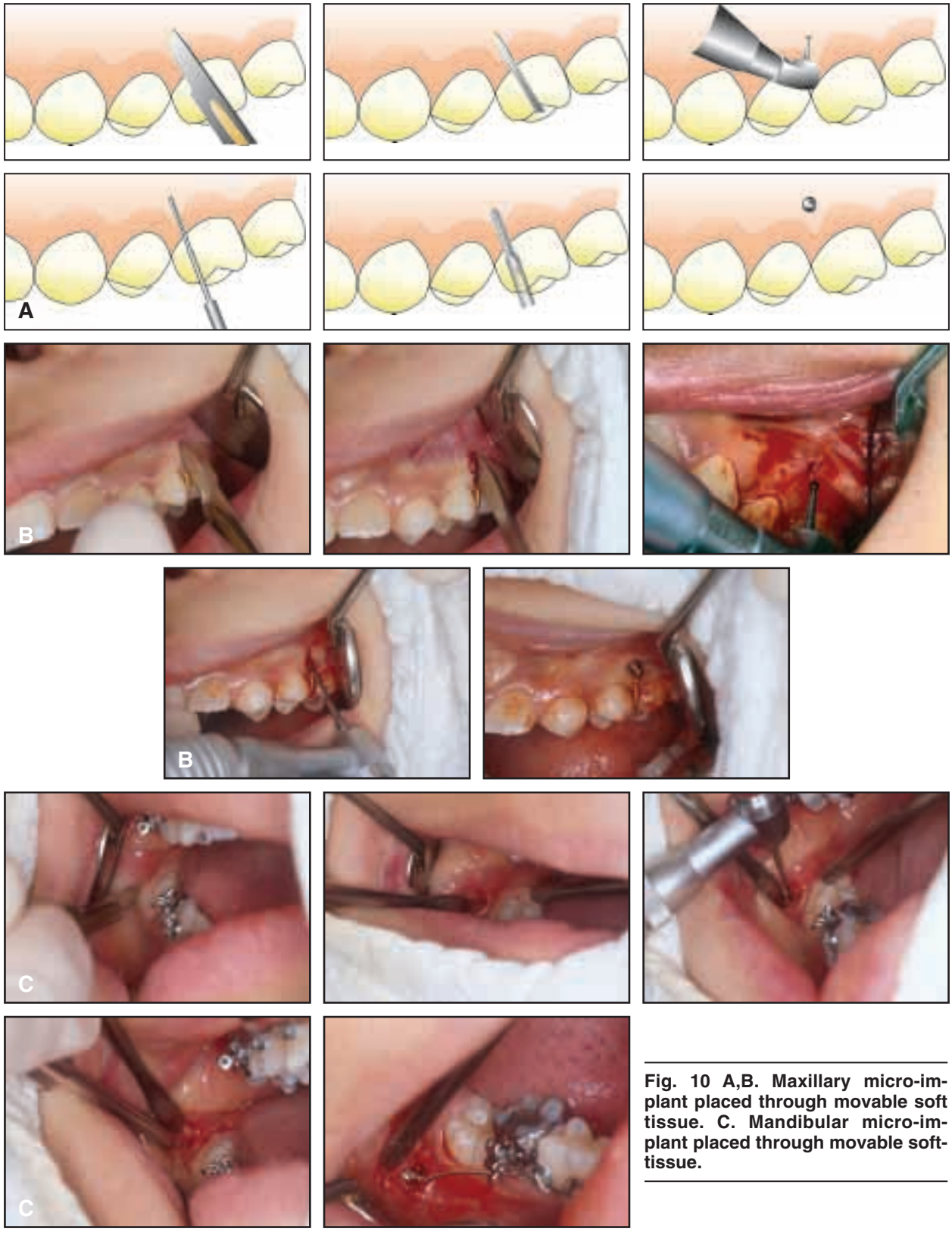

Fig. 10 A,B. Maxillary micro-implant placed through movable soft tissue. C. Mandibular micro-implant placed through movable soft-tissue.

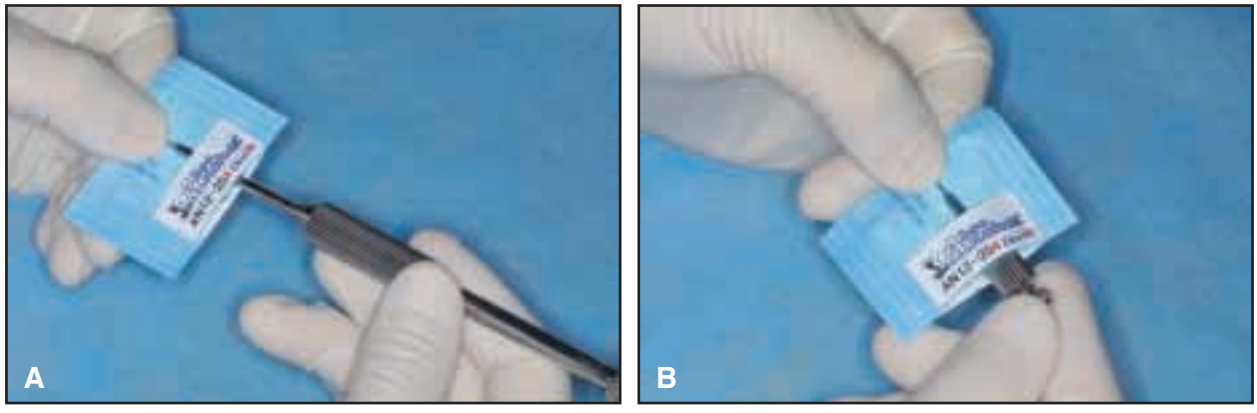

Fig. 11 Long (A) or short (B) manual screwdriver can engage micro-implant inside package.

micro-implant fits tightly, orthodontic forces can be applied immediately (Fig. 2). Light, continuous forces, as supplied by nickel titanium coil springs, are preferable to the more extreme initial forces of elastomeric modules.

Post-Surgical Management

Root damage has not been a problem with micro-implants when they are placed as described above. The roots typically recuperate fully even when severely challenged, however, as with apicoectomies.

Excellent home care, including water irrigation, will greatly increase the chances of success. Inflammation due to inadequate oral hygiene can cause even tightly fitting micro-implants to loosen. Periodic mouthrinses will help ward off inflammation and infection, and antibiotics can be prescribed as needed. Patients seldom need any medication for pain.

Because complete osseointegration does not occur between the micro-implant and bone, implant removal is simple. Engaging the screw head with the driver and turning it in the opposite direction of insertion will easily remove it without local anesthesia. The patient may experience minor discomfort when the implant contacts the soft tissue, but this is less traumatic than an anesthetic needle-stick.

Conclusion

Because patient cooperation is so critical, adequate informed consent should always be obtained before surgery is undertaken. Successful micro-implantation depends on several factors:

- The clinician's skill
- The patient's physical condition
- Site selection and fit
- Oral hygiene

We have noted considerably fewer failures when the implants are placed in areas of attached gingiva rather than movable soft tissue.

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