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AJO-DO

Effects of pilot holes on longitudinal miniscrew stability and bony adaptation

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Introduction: The purposes of this study were to longitudinally evaluate the effects of pilot holes on miniscrew implant (MSI) stability and to determine whether the effects can be attributed to the quality or the quantity of bone surrounding the MSI. **Methods:** Using a randomized split-mouth design in 6 skeletally mature female foxhound-mix dogs, 17 MSIs (1.6 mm outer diameter) placed with pilot holes (1.1 mm) were compared with 17 identical MSIs placed without pilot holes. Implant stability quotient measurements of MSI stability were taken weekly for 7 weeks. Using microcomputed tomography with an isotropic resolution of 6 μm, bone volume fractions were measured for 3 layers of bone (6-24, 24-42, and 42-60 μm) surrounding the MSIs. **Results:** At placement, the MSIs with pilot holes showed significantly ($P < 0.05$) higher implant stability quotient values than did the MSIs placed without pilot holes (48.3 vs 47.5). Over time, the implant stability quotient values decreased significantly more for the MSIs placed with pilot holes than for those placed without pilot holes. After 7 weeks, the most coronal aspect of the 6- to 24-μm layer of cortical bone and the most coronal aspects of all 3 layers of trabecular bone showed significantly larger bone volume fractions for the MSIs placed without pilot holes than for those placed with pilot holes. **Conclusions:** MSIs placed with pilot holes show greater primary stability, but greater decreases in stability over time, due primarily to having less trabecular bone surrounding them. (Am J Orthod Dentofacial Orthop 2014;146:554-64)

Miniscrew implants (MSIs) provide orthodontists greater anchorage control and orthopedic treatment options. Despite their numerous advantages, the success rates of MSIs have yet to reach those of endosseous implants.[1-6] Of the various factors proposed to increase MSI stability, the use of pilot holes remains perhaps the most confounded and controversial. Pilot holes decrease insertion torque during initial MSI placement[7-11] but result in less bone around the MSI after healing.[12]

Pilot holes were first used by surgeons in 1959 to prevent premature failures when placing large pedicle screws for spinal fusion.[13] They were commonly used in the 1980s for orthopedic surgery[14]; craniofacial surgeons were using pilot holes with screws similar to present-day MSIs.[10] Because of their popularity among surgeons, pilot holes were initially drilled when MSIs were introduced during the early to middle 1990s.[10] However, pilot holes fell out of favor during the late 1990s for their potential disadvantages, including damage to nerves, roots, or tooth germs; thermal necrosis; and drill-bit breakage.[15] Concomitantly, the placement of MSIs without pilot holes became popular with the advent of self-drilling MSIs. Pilot holes came back in favor after 2006 because of concerns about screw breakage during placement[7,8,16] and high insertion torque that may be linked to premature MSI failure.[8]

Based on insertion torque, removal torque immediately after insertion, and bone-to-implant contact (BIC) immediately after insertion, pilot holes appear to decrease primary stability. MSIs placed with pilot holes exhibit lower insertion torque than screws placed without pilot holes in both real[7-9,11,15,17] and synthetic

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bone.[7,9-11,15] Although pilot holes placed in wood and porcine mandibles had no effect on pullout forces for MSIs, they decreased the pullout forces for MSIs placed in polyvinyl chloride.[15] Hung et al[17] showed that pullout strength decreased as pilot hole size increased in synthetic bone. Studies have also shown that MSIs placed without pilot holes have higher BIC at placement (evaluated by histomorphometry) than do MSIs placed with pilot holes.[18]

Theoretically, lower insertion torque should reduce the strains produced in bone during MSI placement; this might be expected to have a positive effect on secondary stability.[19] Whether MSIs placed with pilot holes exhibit decreased secondary stability remains controversial. Although greater BIC has been reported after 6 months of healing for MSIs placed without than for those placed with pilot holes,[12] no significant difference between MSIs placed with and without pilot holes was reported after 12 weeks of healing.[20]

It is important to determine the effect of pilot holes on the relationship between primary and secondary stability. This relationship remains unclear because it is difficult to evaluate MSI stability longitudinally without destroying the bone-MSI sample. Resonance frequency analysis, a well-established technique for evaluating the longitudinal stability of endosseous implants, is currently the best noninvasive way to monitor implant stability.[21-24] Resonance frequency analysis produces an electromagnetic signal that excites a metal peg screwed into the implant, and the resonance vibration of the implant is sensed by a transducer in the hand piece. The vibrations are quantified as the implant stability quotient (ISQ), which provides a measure of the implant's stability, ranging from 1 to 100. Resonance frequency analysis was first used to assess MSI stability in porcine models.[25] More recently, it has been shown that resonance frequency analysis can be used to evaluate MSI stability over time in canine models.[26] Most recently, the use of resonance frequency analysis to measure MSI stability has been validated[27] and applied clinically[28] in humans.

Using the Osstell Mentor (Osstell AB, Gotheburg, Sweden), the objectives of this study were to evaluate the stability over time of MSIs placed with and without pilot holes. To better understand the effects of pilot holes on bone healing, bone surrounding the MSIs was evaluated 3 dimensionally with microcomputed tomography, which is more sensitive than histomorphometry for quantifying experimental effects on bone around MSIs.[29-31]

MATERIAL AND METHODS

Six skeletally mature female foxhound mixes, approximately 2 years of age and weighing between 55 and 65 pounds, were used for this study. Foxhound dogs are an established model for investigating peri-implant osseous dynamics; their large jaws allow for the placement of multiple MSIs.[32-37] The Institutional Animal Care and Use Committee at Texas A&M University Baylor College of Dentistry in Dallas, Tex, approved the care of the animals and the experimental protocols.

The MSIs used (Neodent, Curitiba, Paraná, Brazil) were self-drilling and made of titanium alloy; the threaded portions were 5 mm long and 1.6 mm wide (outer diameter). The MSIs were fabricated to have threaded SmartPeg (Osstell AB) accepting heads. To prevent tissue overgrowth, each animal had 6 to 8 MSIs placed on the lingual surface of the mandible. MSIs were placed in the furcations and between the teeth, depending on space availability in each dog. Using random assignment, pairs of MSIs were placed in the same location in both sides of the mandible: one with a pilot hole and one without. The Osstell device (Osstell AB) was used to measure implant stability immediately after MSI placement and every week thereafter until the dogs were euthanized. Bony adaptation was evaluated 3 dimensionally with microcomputed tomography and histologically with fluorescence.

After quarantine and before MSI placement, all animals were sedated with ketamine (2.2 mg/kg intramuscularly) and rompin (0.22 mg/kg intramuscularly) and given a prophylaxis with ultrasonic scaling with chlorhexidine. On the day of MSI placement, periapical radiographs were taken bilaterally and measured to determine screw locations (Fig 1, *A*). The animals were intubated and maintained with 1% isoflurane with oxygen at 1 L per minute. Radiographic measurements were transferred intraorally via a perio probe (Fig 1, *B*), and the sites intended for MSI placement—interdental or interradicular—were marked. Local anesthetic (2% lidocaine with 1:100,000 epinephrine) was administered via local infiltration. A 1.1-mm drill bit (Neodent; 3M, St Paul, Minn) was used for the pilot holes. They were drilled at 1600 revolutions per minute all the way through the cortical bone under copious irrigation (Fig 1, *C*). All MSIs were placed by hand (Fig 1, *D*), with care taken to ensure that each pair of MSIs was screwed into the bone at the same level. Radiographs were taken again after placement to ensure proper MSI placement (Fig 1, *E*). Both analgesics (torbugesic 0.2 mg/kg, 2 mg/mL with 1 mL per animal) and antibiotics (penicillin G 60,000 units/kg) were administered. For histologic evaluations of newly calcified bone, calcein was administered intravenously 2 weeks after MSI placement, and tetracycline was administered 5 weeks after placement.

A total of 40 MSIs were placed (all as contralateral pairs of experimental and control), and the experiment