Peak Torque Values at Fracture of Orthodontic Miniscrews

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Temporary orthodontic miniscrews have become increasingly popular as a means of providing skeletal anchorage for tooth movement.[1,2] If miniscrew anchorage is to be successful, however, the mechanical lock (torque) of the screw in the bone must be able to withstand the applied force.[3] A self-drilling miniscrew is inserted directly through the gingival or oral mucosa into bone; a non-self-drilling miniscrew is inserted through a pilot hole that has been drilled into the bone with a bur.

Previous clinical studies have investigated the torque values (strength) of various orthodontic miniscrews during insertion or removal.[4,5] The present study was undertaken to investigate the peak torque values at fracture of five commonly used, FDA-approved miniscrews in vitro.

Materials and Methods

Twenty miniscrews each from five different manufacturers were tested:
1. Orlus Orthodontic Mini-Implant,* 1.6mm in diameter (1.2mm core diameter), 7mm long.
2. Dual-Top Anchor System,** 1.6mm in diameter (1mm core diameter), 6mm long.
3. LOMAS Quattro,*** 1.5mm in diameter (1mm core diameter), 7mm long.
4. Temporary Orthodontic Micro Anchorage System (TOMAS),**** 1.6mm in diameter (1.2mm core diameter), 8mm long.
5. Ortho Implant,† 1.8mm in diameter (1.5mm core diameter), 6mm long.

Polycarbonate (PC 1000) rods,‡ 1" in diameter, were cut into 100 1"-long sections. For testing, each section was secured by a vise, and a pilot hole with a depth of 3mm and a diameter of 1.3mm was drilled into the center of one end.

The appropriate screwdriver for each miniscrew was inserted into the Jacobs chuck of an Imada torque wrench†† (Fig. 1) and applied to the corresponding miniscrew. The screw was driven into the pilot hole by turning the screwdriver clockwise one revolution every 10 seconds (Fig. 2) until the screw fractured. The torque value at breakage was recorded in Newton centimeters (Ncm). If the miniscrew did not fracture, its peak torque value was recorded when it had been screwed completely into the rod, with the screw head at the rod surface.

A Student t-test was used to determine the statistical significance of the differences in mean torque values among the miniscrew types.

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Fig. 1 Imada torque wrench.

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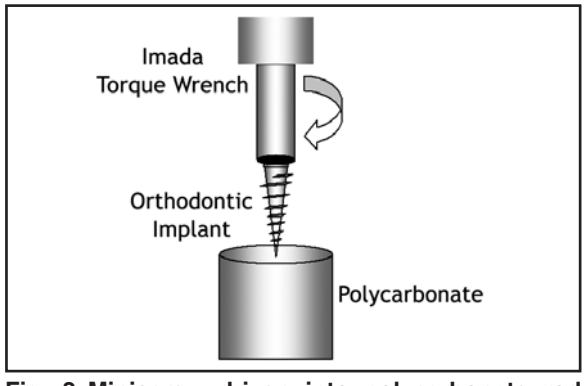

Fig. 2 Miniscrew driven into polycarbonate rod with torque wrench.

Results

All the Orlus, Dual-Top, LOMAS Quattro, and TOMAS miniscrews fractured in testing, but none of the Ortho Implant screws broke (Table 1). The mean torque value of the Ortho Implant miniscrews was significantly higher than those of the other four miniscrews tested. Among the four types that fractured, the Orlus miniscrews had the highest mean torque value, followed by the TOMAS, Dual-Top, and LOMAS Quattro screws. The differences among miniscrew types were all statistically significant ($p < .05$).

Discussion

The results of this study show a direct relationship between peak torque value at fracture and miniscrew diameter, with the largest-diameter screw (Ortho Implant) emerging as the strongest and the smallest-diameter screw (LOMAS Quattro) as the weakest. Furthermore, since all the miniscrews in this test were inserted through 1.3mm pilot holes, the smaller-diameter miniscrews might have required less insertion force than usual, thus increasing their apparent torque strengths.

Another factor that could affect a miniscrew's strength is its shape. With a straight screw (Dual-Top, TOMAS, and LOMAS Quattro), a core of constant diameter is attached to the screw head. On the other hand, in a tapered type (Orlus, Ortho Implant), the diameter of the core gradually decreases from the screw head to the tip, and the diameter is measured at the midpoint of the screw length. This may explain why the Orlus screws showed a significantly higher mean torque value at fracture than the TOMAS screws, even though they have the same diameter. Miniscrew strength could also be affected by the thread design and the material composition—in particular, whether the alloy contains hard or soft titanium.

Previous studies have investigated the strength of various orthodontic miniscrews during insertion

TABLE 1
PEAK TORQUE VALUES AT FRACTURE (NCM)

	Orlus	Dual-Top	LOMAS Quattro	TOMAS	Ortho Implant
Fracture	Yes	Yes	Yes	Yes	No
Mean	58.33	29.72	23.26	32.44	78.24
S.D.	8.21	1.25	0.34	1.11	3.84
Range	45.53-75.81	28.13-32.08	22.59-23.72	30.39-34.46	71.51-84.96

or removal in vivo. In a study of 41 patients, Motoyoshi and colleagues found mean peak insertion torque values for the ISA Orthodontic Implant‡‡ (1.6mm in diameter, 8mm long) of 8.3 Ncm in the maxilla and 10 Ncm in the mandible.[4] A pilot hole 1.3mm wide and 8mm deep was drilled into the buccal plate before insertion of each miniscrew. Büchter and colleagues reported that six of 102 AbsoAnchor§ miniscrews (1.1mm in diameter) and two of 98 Dual-Top miniscrews (1.6mm in diameter) fractured during insertion, while one AbsoAnchor and one Dual-Top miniscrew fractured upon removal.[5] The torque values at breakage were not measured. For the unfractured miniscrews, however, the authors found a mean removal torque value of 2.99 Ncm for the unloaded AbsoAnchor and 11.11 Ncm for the unloaded Dual-Top at day 70. Carano and colleagues reported mean torque strengths of 37.4 Ncm for their 1.3mm-diameter Miniscrew Anchorage System§§ screws and 48.7 Ncm for the 1.5mm-diameter screws, but did not explain their testing method.[6]

In the present study, the peak torque values at fracture of all miniscrews tested were well above previously reported clinical values. Under certain circumstances, however, miniscrews may still break during insertion or removal. Factors involved include the insertion site, bone density, and whether a pilot hole is drilled. The risk of fracture is greater, for example, if a miniscrew with a small diameter is placed, without drilling a pilot hole, in the mandibular posterior region or midpalate of an adult with high bone density. Fracture is also more likely if the insertion angle is changed during placement. In addition, if a miniscrew encounters a structure such as a root, the torque needed to overcome the obstacle can increase the stress along the screw shaft and threads, which may lead to fracture.

If a miniscrew does break during insertion, the screw fragment embedded in the cortical bone can be surgically removed. A full-thickness flap is made, bone is cleared from around the fractured screw, and reverse torque is applied to the screw to remove the fragment. If the fragment encroaches on vital structures, however, it should be left in the bone, considering that orthodontic implants are made of biocompatible titanium.

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§Dentos, Inc., 258 BunJi, Dong-In Dong, Jung-Gu Taegu, Seoul, Korea; www.dentos.co.kr.
§§Micerium S.p.a., via Marconi 83, 16030 Avegno, Genova, Italy; www.micerium.it.

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