

Failure Torque of Bioabsorbable ACL Interference Screws

Objective

The objective of this study was to evaluate the torsional strength of bioabsorbable screws using a quick set epoxy mold test fixture. Table 1 lists the manufacturer, size, material, and lot numbers of the screws used in this study.

Table 1

| Device | Screw Size | Material | Lot # |
|--|------------------------|----------|----------|
| BioScrew Linvatec Largo, FL | 7x25 mm | PLA | 00192667 |
| Bio-Intf. Screw Arthrex Naples, FL | 7x23 mm | PLA | 12048 |
| BIORCI® Smith & Nephew Mansfield, MA | 7x25 mm (8 mm Head) | PLA | 410922 |

Methods

Torsional strength testing with an epoxy bone model was evaluated using the BIORCI Interference Screw (Smith & Nephew), BioScrew (Linvatec) and the Bio-Interference Screw (Arthrex). Analogous screw sizes from each manufacturer were used to allow direct comparison of results. Screws were placed in a mold and quick set epoxy was poured around the screws, fixing them securely in place. Using an Instron testing machine and the appropriate driver tip, the screws were torqued clockwise (direction of screw insertion) simulating in-vivo screw insertion. Torque versus rotation curves were recorded and the peak loads were averaged and presented in Figure 1.

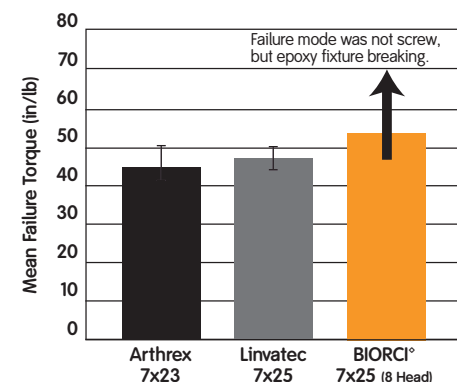


Figure 1 7 mm Screw Comparison Using Epoxy Mold Fixture

Materials

1. Quick set epoxy.
2. Three molds (acetal) measuring 6" x 1.5" x 2" to hold epoxy/screws.
3. Five 7 x 25 mm (8 mm head) BIORCI Interference Screws (REF 7207554), with BIORCI driver (Smith & Nephew).
4. Five 7 x 25 mm BioScrew Interference Screws (REF C8031), with BioScrew driver (Linvatec).
5. Five 7 x 23 mm Bio-Interference Screws (REF AR-1370B), with Bio-Interference driver (Arthrex).
6. Instron 4411 electro-mechanical test machine (Instron, Canton, MA).

Test Procedure

1. Mount five of each screw in a quick set epoxy block (6" x 1.5" x 2") with the head of the screw protruding 5 mm from the top surface of the epoxy. Make sure to keep each screw perpendicular to the top surface of the epoxy block. The screws should be separated by at least one inch from each other.
2. Make up the epoxy block in 5–10 mm layers, allowing each layer to cure for 5–10 minutes and then allow a full 16 hours to reach maximum hardness.
3. Load the Instron test machine with the torsional testing head and the appropriate driver shaft.
4. Clamp the epoxy block into the Instron base, aligning the driver with the screw drive feature.
5. Insert the driver into the screw with an axial preload of 2 lb.
6. Apply torsional force to the driver, at a rate of 1000 deg./min., and record maximum torque while noting the failure mode.
7. Repeat this test for of each screw.

Results

Failure torque measurements indicated that the BIORCI® screw is at least 22% stronger than either the BioScrew or Bio-Interference Screw (see Figure 1).

It is very important to note not only the average torque values, but the failure modes as well. The Arthrex screw, which had the lowest strength, had two failure modes. The first failure mode was a crack along the parting line.

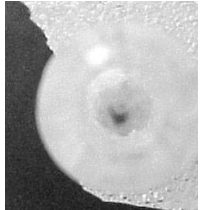


Figure 2a

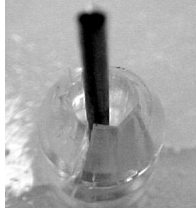


Figure 2b

The other failure mode was the hex of the screw being stripped out by the driver (see Figures 2a and 2b).

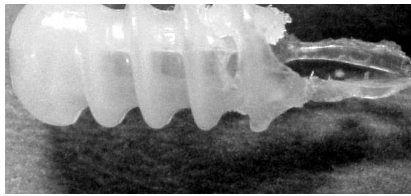


Figure 3a

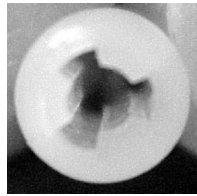


Figure 3b

All of the Linvatec screws sheared in half and the Tri-Lobe/driver interface did not strip (see Figures 3a and 3b).

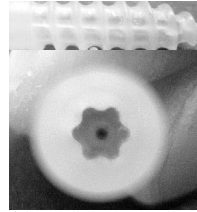


Figure 4

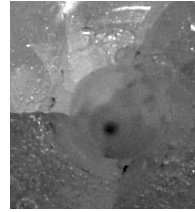


Figure 5

The BIORCI screw did not break or crack and the driver did not cause stripping of the screw Torx® (see Figure 4). The failure mode was crack propagation in the epoxy mold due to the high degree of torque exerted on the screws (see Figure 5). More testing is necessary to determine the ultimate failure mode/strength of the BIORCI screw. A stronger base material is needed to test the true limits of the BIORCI screw.

Discussion

The study of these three interference screws demonstrates that the driver/screw interface design is an important factor in determining the insertion strength of the screw. The Torx design has a larger surface area than a hex thus improving torque transfer and increasing its torsional strength as seen by the stripping of the hex by its driver. The Tri-Lobe design also has a large surface area, but its design incorporates abrupt changes in its cross section thus creating sharp corners producing stress concentrations. The smooth round radii on the torx design minimizes stress concentrations improving its maximum torsional strength. As more ACL procedures, using absorbable materials, are performed each year, it is important to minimize screw failure during insertion into hard bone. Screw breakage often results in a delay in surgery when the screw must be removed or poor fixation strength if it is left in. Results from this study show substantial differences between these designs, but further study is needed to correlate specific design features to screw strength and failure.