A New Variable Depth Control Drill Provides Surgeons Intra-Operative Skive Detection Without The Use Of Fluoroscopy.

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(583 words without title and names – body is 475)

Background/Purpose: Drilling in close proximity to joints and spinal elements risks penetration of the protective cortex. The concept of drilling toward "safe zones" was developed from anatomical studies to help surgeons more safely penetrate or plunge with their drill or screw. Standard drills provide limited tactile feedback, especially in osteoporotic bone or when the angle of the cutting edge of the drill bit is oblique to the endosteal cortex or skiving. Joint penetration and cortical skive detection are highly reliant on the use of intra-operative fluoroscopy. The Variable Depth Control (VDC) device, a new handheld robotic drilling technology, senses drilling torque in real time and displays it on a GUI (Graphical User Interface). With VDC technology, the surgeon can detect impending cortical and joint penetration at varied skive angles without the routine use of fluoroscopy.

Methods: Bi-cortical surrogate bone blocks (Sawbones part number 1522-1132, Pacific Research Laboratories, Vashon, WA) were used as bone models. A handheld VDC drill was tested at various skive angles. Slopes of the skiving torque curves where measured. CT scans of the bone models where obtained to verify actual skive angles and distances, see Figure 1. The skive distances were also calculated using the known cortex thickness of 4 mm using the law of sines (right triangle) and verified from the torque curves' shapes.

Results: The CT skive angles correlated with the torque curve angles. The Pearson's correlation coefficient was calculated, r = 0.92 (r2 = 0.84), see Figure 2.

Conclusions: Penetrating a joint (see Figure 3), pedicle, pelvic brim, or cranium, can be difficult to detect especially in osteoporotic bone and when the drill penetrates at oblique angles to the cortex. Surgeons habitually use fluoroscopy to check their position, often using continuous fluoroscopy. Despite this, penetration into joints, tendons, and other vital structures are well documented across all specialties using drills. Excessive use of fluoroscopy wastes operating time and exposes the patient, surgeon, and OR personnel to unneeded radiation. The VDC drill gives true 3D awareness as the rise in the slope can be detected on any axis whereas fluoroscopy only detects pending penetration in one plane, unless the C-arm or body part is rotated. The VDC drill torque curve rises at angles that correlate with the angles at which the drill contacts and penetrates the denser cortex, this allows the surgeon time to redirect the drill away from that cortex keeping the bit endosteal, or down a canal like a pedicle.

VDC technology does not use radiation, guidance systems, preoperative CT's, robotic

arms or other expensive and time consuming techniques. The VDC drill, with its wireless GUI output is portable, light and inexpensive. Its benefits may lead to a reduction in habitual fluoroscopy use during common screw placements like femoral head, humeral head and pedicle screws. Future VDC studies with cadaveric bone are planned followed by human clinical trials.

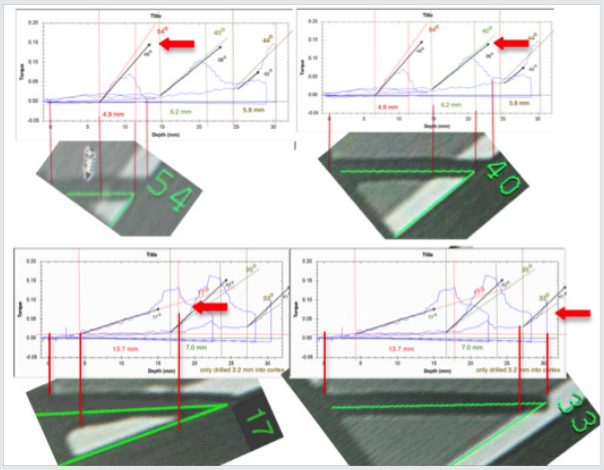

Figure 1. GUI graphs with 3 skives on each graph, CT's below each graph are matched to their curve (red arrow). CT angles (colored font), measured angles (black font) and distances through the cortex are listed on the graphs for all 6 skives.

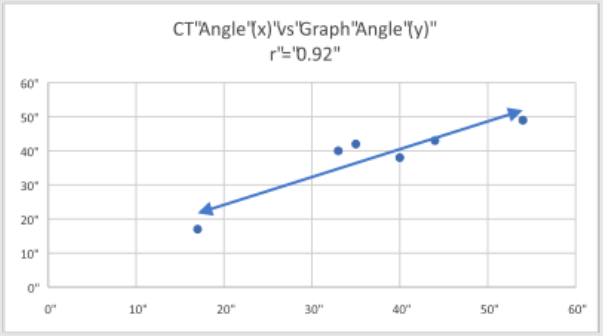

Figure 2. Correlation between CT angles and measured angles.

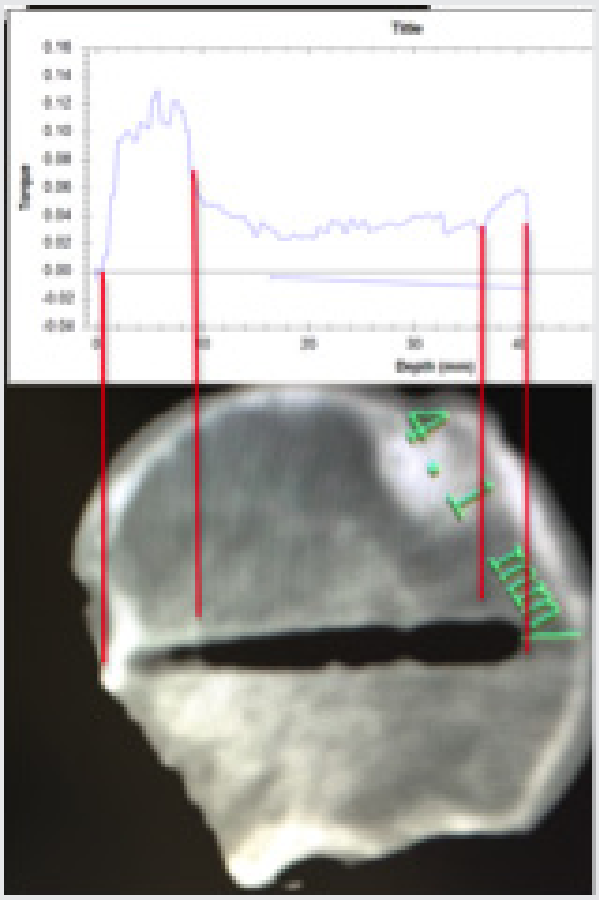

Figure 3. GUI and CT from human hip using VDC 3D awareness to drill up to the edge (less than 5 mm) of the hip without fluoroscopy. Near cortex torque measured at 0.12 Newton meters, decision to stop drilling when 50% of that torque was re-obtained produced the desired result in each of three hips.