Cranial Drilling Tool with Retracting Drill Bit Upon Skull Penetration

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1 Background

Penetrating the skull to measure intracranial pressure is an important intervention for diagnosing potential problems following head trauma. Studies show that 1.7 million people suffer from head injury annually in the U.S., totaling $60 billion in costs [1]. 275,000 of those injured annually are hospitalized and 52,000 will eventually die as a result of that injury [1]. The risk of pressure induced damage can be reduced by penetrating the skull with a small diameter hole and placing sensors inside for intracranial pressure (ICP) monitoring or draining excess fluid [2]. A trained neurosurgeon is required to perform the drilling with current devices on the market. Although frequent monitoring has been correlated with a decrease in mortality rates, only a small percent of patients receive ICP monitoring due to the lack of availability of a sufficient number of neurosurgeons [3]. The cranial drilling device described in this paper is designed to allow non-neurosurgical personnel to safely penetrate the skull.

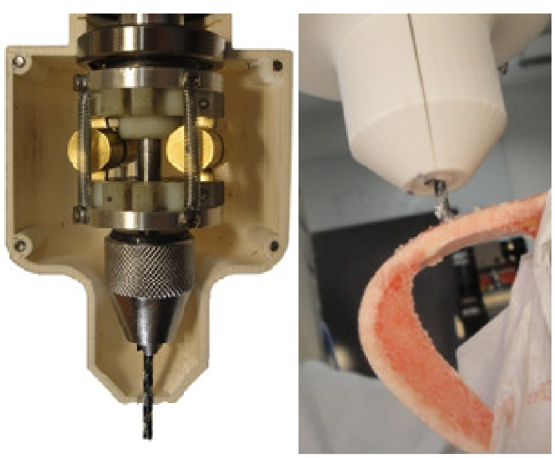

Fig. 1. (left) Device prototype shown with casing open (right) Enclosed device drilling 5mm bovine bone sample

2 Methods

This handheld, portable, cranial drilling device (shown in Fig. 1) can be used with varying diameter drill bits to create holes in the skull without plunging into underlying brain tissue. The device relies on a dynamic bi-stable mechanism that supports drilling when force is being applied to the drill, but retracts inside a protective sheath (visible in Fig. 1) when the force is reduced on penetrating the skull. The bi-stable mechanism operates by a force balance between the reaction force due to drilling and centrifugal forces due to rotating masses as shown in Fig. 2a. At the moment of penetration, the reduced reaction force causes the linkages to change from the drilling position in Fig. 2b to the collapsed position in Fig. 2c.

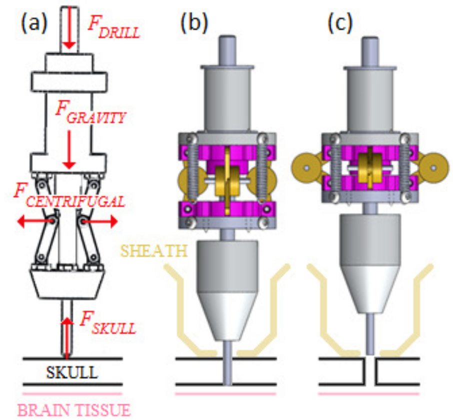

Fig. 2. Cranial drilling device retraction mechanism

3 Results

Initial testing on ex-vivo animal bones has verified that, after bone penetration, the retraction mechanism successfully withdraws the drill bit before damaging soft tissue beneath the skull. A reload mechanism allows the user to reset the device to the drilling position and create additional holes.

4 Interpretation

The device is designed to access the brain in the emergency room, disaster relief, or in military settings. It is safe, portable, and versatile. Currently, this device is an attachment that can be chucked into a standard drill of minimum spinning speed. However, future iterations of the device will include a specified motor, battery, and disposable sterile drill bits. Due to its safety features a general surgeon could operate the device, greatly increasing the availability of pressure monitoring for head trauma patients. The clinician needs no prior information regarding skull thickness at the point of drilling. Additionally, although this device was designed for cranial neurosurgery, the mechanism is also applicable for increasing safety in other drilling procedures such as inserting screws into the vertebrae, pelvis, or puncturing the sternum to access the pericardium while avoiding damage to delicate organs, nerves, or blood vessels.

References

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