The Problem with Current Impaction Technique

Total hip arthroplasty (THA) is an increasing cost on the healthcare system. Revision surgeries represent more than 8% of hip replacements and have a 61% increase in cost\(^3\).

Impact force affects fixation strength

Strong fixation of the taper junction reduces potential for micromotion and associated failure mechanisms.

Impaction force discrepancies in literature and operating room.

Current manual striking technique cannot guarantee consistent impaction with the required force\(^3\).

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### Solution

**Goal:** Increase the lifetime of the taper junction in a cementless THA through regulated impaction of the femoral head.

The aim of this project is to develop a femoral head impactor that:
- Minimizes the number of strikes required to deliver force
- Delivers 6 kN of force
- Requires 5 minutes to use from start to end
- Costs $800 CAD to manufacture
- Is easy for a surgeon to use

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### Design

- **Simple Crank Mechanism and Force Limiter:**
  - Cranking is limited to 10 revolutions with a maximum application force of 4.2\(\text{ N}\), ensuring desired impaction force is easily applied.
  - Ball-bearings reduce friction during cranking.

- **Reliable Compression Mechanism:**
  - Non-backdrivable gears prevent accidental triggering of the device.

- **Effortless Release Mechanism and Minimization of Recoil:**
  - The release lever is simply lifted to disengage the worm from the worm gear.
  - High strength ball-bearings reduce friction as the shaft rotates during release.
  - The impacting mass is not rigidly attached to the compression spring limiting recoil experienced by surgeon during impaction

- **High Strength Spring:**
  - A custom stainless steel spring is tailored to meet the objectives made of this application and deliver 6kN of force to the femoral head.

- **HDPE Impactor Tip**
  - The high stiffness ensures complete force transmission to the implant and ensures the smooth surface doesn’t scratch or damage the implant.

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### Key Components and Validated Safety Features

- **Operating Room Integration**
  - This device seamlessly integrates into the operating room.
  - Ethylene Oxide sterilization is compatible with all materials present in device
  - Less than two minutes to use with minimal training required
  - Compact design minimizes repetitive striking motion for surgeons

### Conclusion and Future Work

At only $750 this device delivers quick and consistent impaction, increases the lifetime of the taper junction, reduces need for revision surgery, and drastically benefits patients globally!

**Future work includes:**
- Physical prototype manufacturing for accurate cost comparisons, cyclic load testing, and human factors testing.
- Additional features such as a positioning sensor.

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### References