# Low-plasticity burnishing improves fatigue strength

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Low plasticity burnishing is a surface enhancement method that produces a deep layer of compressive residual stress with minimal cold working. It is a flexible process, capable of being implemented with a wide variety of CNC machine tools. The benefits of compressive residual stresses to boost fatigue strength in metallic components have long been recognized. Achieving deep compression with low cold work reduces relaxation of the protective compressive layer either thermally during exposures at service temperatures, or mechanically due to overload or impact.

This article describes how the technology can be applied to improve fatigue life of implanted total hip prosthesis systems.

**Hip implants**

Implanted total hip prosthesis (THP) systems are subjected to a spectrum of cyclic loading from normal day-to-day activities. Chances of high cycle fatigue failure increase with patient size and level of activity.

Modular THP construction has become more widely applied because it gives the surgeon the opportunity to interoperatively choose the proper size prosthesis, and offers flexibility in treating a wide spectrum of hip defects and patient anatomies. Modular systems are typically held together by means of a tapered interlock.

However, fretting can take place along the contact of the taper junction because of small displacements between the two connected subcomponents. Surface micro-cracks from fretting damage can cause a significant reduction to the high cycle fatigue strength of the THP.

To counter this possibility and raise fatigue strength, low plasticity burnishing can be applied. A product-specific LPB process was developed and applied to the modular neck taper junction of a Ti-6Al-4V THP, as shown in Fig. 1. LPB produced a compressive residual stress field with an improved surface finish. High-cycle-fatigue tests demonstrated complete elimination of fretting fatigue failures in the processed area of the taper junction, as well as a substantial increase in overall THP fatigue strength.

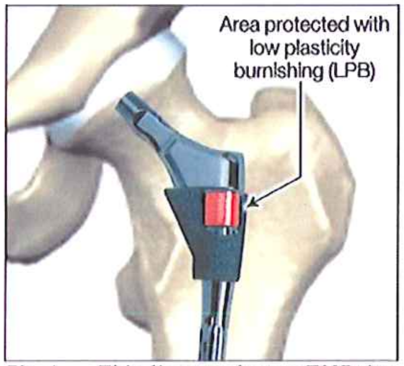


*Fig. 1 — This diagram shows a THP titanium neck segment, metaphyseal (cut away), and femoral stem.*

The design of the compressive residual stress field of the hip stem was based on finite element modeling. The model served to estimate both the in-service applied stresses and the LPB residual stresses in the neck stem segment.

To test the design, forces were applied to the femoral head to simulate the loads sustained during fatigue testing. Residual stress results measured by X-ray diffraction on LPB processed neck segments were then placed in the FE model to accurately simulate the compression imparted by the LPB process.

High cycle fatigue tests were performed on untreatedand LPB treated neck segments in accordance with ISO standards 7206-4 and 7206-8. LPB improved the fatigue strength of the hip stem greater than 40% and increased the life by over 100X. The LPB process completely eliminated fatigue failures from the treated neck taper region. **MPMD**

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