NANOINDENTATION STUDY OF INTERFACES BETWEEN STRONTIUM-CONTAINING HYDROXYAPATITE BONE CEMENT AND BONE IN A RABBIT HIP REPLACEMENT MODEL

Ni GX[1], Lu WW [1], Ngan HW [2]
1 Department of Orthopaedics and Traumatology, The University of Hong Kong, Hong Kong
2 Department of Mechanical Engineering, The University of Hong Kong, Hong Kong, Hong Kong
Corresponding author: Lu WW, wwlu@hkusua.hku.hk

INTRODUCTION

Many bioactive bone cements were developed for total hip replacement, and found to bond with bone directly [1,2]. However, the mechanical properties at the bone/bone cement interface are not fully understood. The aim of the present study was to investigate the interfacial mechanical and morphological properties of newly formed tissue by nanoindentation and microscopic analysis.

METHODS

Unilateral hip replacement was performed with Sr-HA cement in rabbits. Six months later, the femurs were removed and cut into parallel sections. Observations were taken at the interface of Sr-HA cement and cancellous bone for metaphyseal sections and interface of Sr-HA cement and cortical bone at diaphyseal sections.

RESULTS AND DISCUSSION

For the interface between Sr-HA cement and cancellous bone, osseointegration was widespread. Many multinucleus cells covered the surface of the cement, and resorbed the superficial layer of the cement. New bone infiltrated into Sr-HA cement. An interface with a thickness of about 10 μm was found covered on the Sr-HA cement by scanning electron microscopy (SEM). By nanoindentation testing, sharp increase was found at the interface in terms of Young's modulus and hardness (Figure 1).

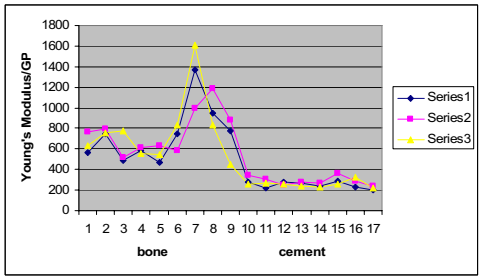

Figure 1: Young's modulus of cancellous bone, interface and Sr-HA cement. The peak was at the interface.

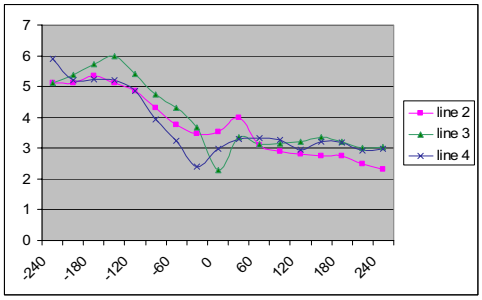

Figure 2: Young's modulus of cortical bone, interface and Sr-HA cement. A smooth transition was found.

As for the interface between Sr-HA cement and cortical bone, intimate contact was observed without fibrous layer intervening by histological and SEM observations. Nanoindentation test showed that, in terms of Young's modulus and hardness, a smooth transition was observed from bone, interface, to Sr-HA cement (Figure 2).

The cement/bone interface is crucial to the stability of the cemented femoral component. However, its mechanical property is far from full understanding because traditional mechanical tests, such as bend testing and compression testing, are not suitable due to specimen size requirements. Fortunately, nanoindentation may offer valuable information about intrinsic mechanical properties, and has been used to evaluate mechanical properties near the implant/bone interface [3].

In the present study, nanoindentation test showed that the Young's modulus and hardness at the interface were higher than those at the Sr-HA cement and cancellous bone. This was further supported by the histological observation. Osseointegration of Sr-HA cement with cancellous was widespread, which is similar to calcium phosphate cement,[4]. Fujita et al found that the bone/cement interface was the weakest point mechanically for the cemented femoral component when a bioactive bone cement consisting of glass powder and Bis-GMA based resin was used in canine total hip arthroplasty [2]. The impregnated ceramic particles which are incompatible with the acrylic cement matrices might be blamed.

Different mechanical properties between cement/cancellous bone interface and cement/cortical bone interface may be explained by the different response of Sr-HA cement to cancellous bone and cortical bone. Further study is needed to explore the way in which the Sr-HA cement bonds with cortical bone.

CONCLUSIONS

Under weight-bearing conditions, intimate contact was found between Sr-HA cement with both cancelllous and cortical bone. The stable interface was further proven by nanoindentation. Sr-HA cement has potential to be an alternative to the conventional bone cement in total hip replacement.

REFERENCES

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