2.4 Analysis and Investigation of the Adhesive Strength of Ceramic and Bone Cement in Knee Arthroplasty

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Introduction

Ceramic total knee arthroplasty is not popular at present. Though good experiences of total hip replacement showed that ceramic-ceramic coupling proved itself as a long-time implant. Knee endoprosthesis should be fixed in place with bone cement. The implant-cement interface affects significantly the mechanical situation of the total system and can cause loosening of the implant. As loosening of the implant is one of the most common reasons for failure of the prosthesis, measurements of the strength of these bonds are of great interest.

Purpose

This study is attending to find practical ways for strengthening ceramic / bone cement interface via mechanical and chemical surface treatment. Furthermore the thickness of the cement layer as well as an immersion in moisture environment was tested on adhesive strength of the ceramic-cement interface. In addition, the adhesive strength of ceramic / bone cement interface and the coupling of TiAl6V4 / bone cement was compared.

Method

To determine the adhesive strength of ceramic / cement through tensile tests on an universal testing machine (Instron 8561 with gimbal suspension), wafers of zirconiumdioxid- and platelet reinforced aluminumoxide-ceramic (BIOLOX® delta, CeramTec AG) were bonded to metal stamps and coupled by bone cement (Palamed® G, Biomet-Merck). Several surface structures (grooves, drills) and surface roughness created by sandblasting and polishing were applied to the ceramic surface.

To gain a chemical coupling between bone cement to ceramic some specimens were conditioned by silanisation and by an additional silicatisation. In order to examine the hydrolytic resistance of the ceramic-cement compound the specimens were immersed for 30, 60 and 80 days in physiological saline solution at 37°C.

The adhesive strength of TiAl6V4 / cement was tested with smooth and sandblasted surface.

Five specimens for each condition were tested to ensure a representative average value.
Results

The examination of the thickness of the cement layer showed that with thinner cement layer an enhancement of tensile bond strength can be determined. Untreated test bodies with a cement layer of 2 mm reached a tensile bond strength of 6.17 MPa (SD: ±1.38 MPa), whereas with a thinner cement layer of 0.7 mm the tensile bond strength increased to 14.90 MPa (SD: ±2.54 MPa). The reasons are more shrinkage stress and inhomogenety in thicker cement layers, which results in a lower tensile bond strength (Fig.1).

![Figure 1: Delaminating of structured samples BIOLOX® delta / Palamed® G.](image1)

Because of formation of a chemical bonding between ceramic and bone cement by silanisation the tensile bond strength stepped up significantly (Fig.2).

![Figure 2: Delaminating of chemical activated samples BIOLOX® delta / Palamed® G.](image2)

The increase of the adhesive strength by silanisation showed best results using polished specimens with the lowest surface roughness. Silanisation strengthens only specific adherence, because mechanical adherence on a smooth surface is marginal.

Silanisation improved tensile bond strength of the polished specimens to 135%, whereby the increase at untreated specimens was 70% and at sandblasted specimens 10%.