The Morphology of Polymethylmethacrylate (PMMA) Bone Cement

Surface Structures and Causes of their Origin*

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Summary. This study deals with the correlation between the polymerizing bone cement and the surrounding tissue. The surface structures of bone cements, polymerized in air, in tissue medium (in vitro) and in human bone during implantation were investigated and compared with the contours of the tissue of the implant bed. Basing on the dimensional differences it was differentiated between contours of 1st order and 2nd order: contours of 1st order are within the macroscopic range, contours of 2nd order within the microscopic range. The surface of bone cement polymerized in living human tissue differed essentially from samples polymerized under laboratory conditions. The differences are to be seen macroscopically in the coarse relief as well as microscopically in the shape and the connection of the superficial methylmethacrylate beads. Bone cements, polymerized in air show an ideal, even and closed surface. Bone cements, polymerized in tissue medium exhibit macroscopically some wrinkles, in the microscopic range their contours are either closed (samples prepolymerized at 22°C) or partly open and partly closed (samples prepolymerized at 24°C). The surface of bone cement implants, retrieved from human bones are characterized macroscopically by a marked wrinkled and papillary relief, microscopically by flattened beads, and most often by an irregular, rough and open surface with isolated beads giving almost the impression of a porous surface structure.

* Dedicated Professor Dr. E. Uehlinger on his 80th birthday

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The character of the surface of the bone cement originates from external, mechanical influences, from changes in the volume of the bone cement and from effects of the surrounding tissues. The surface of the bone cement implanted in human bone conforms exactly with the contour of the adjacent tissue; the tissue contour is in fact a negative of the cement surface. The incomplete connection between the superficial PMMA beads seems to be of some practical value: In areas, where the PMMA beads are largely isolated, the mechanical stressability of the "polymer composite" is relatively low. Under high load, beads and bead-clusters may break off the surface. Shattering of bone cement implants possibly may start from such an open, porous surface area where PMMA beads are extensive isolated.


Die in den menschlichen Knochen implantierten Knochenzemente unterscheiden sich in ihrer Oberflächenstruktur wesentlich von den unter Laborbedingungen polymerisierten Proben. Die Unterschiede...
Bone cement based on methylmethacrylate is nowadays widely used in orthopaedic surgery for the fixation of joint endoprostheses in living bone. This method was conceived and introduced by Charnley (1959). In spite of the clinical experience for over 20 years, sufficiently reliable data is still not yet available, for example, on the interactions between the cement, implant and the adjacent tissues. We therefore studied the macro- and micromorphology of the boundary surfaces between bone and bone cement. The methods applied, the results obtained and the conclusions drawn by this investigation will be described in the following sequence:

1. **Introduction**

Bone cements are chemically methyl esters of methacrylic acid. They are commercially available under the trade names CMW-Bone Cement, Palacos, Simplex, Sulfix-6, etc. These preparations consist of two components, a powder and a liquid, which are mixed just prior to implantation in amounts strictly specified by the manufacturer, the powder to liquid ratio usually being 2:1 (for Sulfix-6 2.5:1).

The **powder component** is polymerized methylmethacrylate (= polymer, PMMA) in the form of minute spherical beads measuring 20—160 μm. With CMW in addition the powder consists of comminuted polymer pieces ranging in size from