Bone remodeling after PIP joint arthroplasty using pyrocarbon, a material isoelastic to bone.

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Introduction
The proximal interphalangeal (PIP) joint is important for grip function of the hand. In primary and posttraumatic osteoarthritis, contracture and pain often develops, which lead to limitations in daily activities. In 2001 the Ascension Pyrocarbon PIP-prosthesis was introduced for joint replacement in PIP osteoarthritis. Pyrocarbon is a specific form of carbon, durable, tissue compatible and wear-resistant compared to previous materials used for small implant arthroplasty. Pyrocarbon has an elastic modulus similar to cortical bone, thus minimizing the shear in the interface and relative motion between the prosthesis and surrounding bone in loading and bending/shear.

The Ascension Pyrocarbon PIP-prosthesis was introduced at our institution in December 2001 and all patients have been followed prospectively at one, two and five years. Our short-term results have been published showing good pain relief. The publications from other centers also show good short to medium term results with decreased pain and low revision rates, but in some centers, concerns have been raised regarding the fixation and prosthetic migration. In the present study, we report the clinical but in particular the radiographic analysis of the Ascension Pyrocarbon prosthesis with special reference to the osseous integration and remodeling around the implant, which appear to be different to an uncemented or cemented metal prosthesis.

Methods: Thirty-four joints in 24 patients were operated between November 2001-October 2005. The patients were followed prospectively at 1, 2 and 5 years and range of motion (ROM) and grip strength were recorded. The subjective outcome was evaluated using VAS scores, COPM (Canadian Occupational Performance Measure) and DASH (Disabilities of the Arm, Shoulder and Hand). Radiographically, the prosthesis position and the osseous reaction around the prosthesis were recorded.

Radiograms were taken in PA and lateral projections, using digital storage phosphor plates or a digital amorphous silicon flat-panel detector. Image review was performed using Sectra PACS IDS 7. The proximal and middle phalanges were measured on posteroanterior (PA) images from the joint surface of the MCP-joint or DIP joint, respectively, to the end of the prosthesis stem.

MIGRATION; All implants were scored on lateral images according to the index proposed by Sweets & Stern describing the migration of the prosthesis within the medullary canal (Fig 1).

Fig 1. MIGRATION; Dorsal, solar and coronal migration of each implant within the medullary canal were defined using a four point scale: 0-well aligned; 1-macroscopically evident migration; 2-severe migration (adapted from Sweets and Stern)

OSSEOUS REACTION; To evaluate the mechanobiologic integration, a new scoring system is proposed (Figure 2). The osseous reaction to the load and the stability of the inserted prosthesis categorized into four grades.

Fig 2 OSSEOUS REACTION; In grade A, no osseous reaction is found around the prosthesis. Grade B represents a well-integrated implant where the pyrocarbon shell is surrounded by a sclerotic bone reaction. In grade C, the implant is surrounded by a more or less ill-defined osteolytic reaction, suggesting motion of the implant. In grade D, a radiolucent zone surrounds the entire prosthesis.

Results: Three patients were revised. In the 21 non-revised patients, pain at rest (VAS) improved from median 3.5 cm preop to 0 cm at 5 years (p<0.001) and pain at activity (VAS) from 6.5 cm preop to 0 cm at 5 years (p<0.001). ROM (48° preop and 54° at 5 years) and grip strength were unchanged.

Discussion: Although ROM and grip strength remained unchanged, the clinical results were excellent with 20/21 non-revised patients pain free at rest with VAS 0 at the 5-year FU.

Significance A joint prosthesis made of pyrocarbon is isoelastic to cortical bone and behaves differently than an uncemented or cemented stiffer metal prosthesis. A true aseptic loosening is less likely as the prosthesis and surrounding bone deform in concert, minimizing the relative motion in the interface. Instead a slow remodeling of the surrounding bone takes place as a reaction to the applied forces. We propose a new grading system for the osseous reaction around a pyrocarbon prosthesis.