CT-SCANNING AS A TOOL FOR CHARACTERISING GLENOID FIXATION FAILURE

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INTRODUCTION:

Glenoid loosening is the main cause of the relatively high failure rates in shoulder arthroplasty[1]. Examining plane radiographs for the existence, size and progression of radiolucent lines around the fixation of the implant is the standard methodology used in in-vivo investigations of glenoid loosening. However, the results of this methodology are generally accepted to be very unreliable. This paper presents a new methodology using CT scans for evaluating the state of the bone-implant interface.

The use of CT scans to evaluate the state of the implant fixation in clinical practise has been attempted before but without success due to significant artefacts caused by the presence of the metallic humeral head[2]. The methodology presented in this paper dramatically reduces if not totally eliminates these artefacts.

METHODS:

Using standard surgical techniques 12 glenoid implants were inserted into 6 cadaver scapulae and 6 polyurethane bone substitute samples. The samples were then mechanically tested in a biaxial apparatus simulating physiological repetitive loading of the implant-bone specimen according to the standard test method for testing of glenoid loosening (ASTM F 2028-02 [3]). The specimens were CT scanned immediately postoperatively, and at 1.000, 5.000, 10.000, 30.000, 50.000 and 70.000 cycles. At 70.000 cycles the specimens still appeared grossly intact and the tests were stopped. The specimens were physically sectioned using a high precision band saw. The implant fixation area was therefore exposed and examined for failure using microscopy. For the purposes of validating the proposed CT-scanning technique, the observations using microscopy were compared to the observations using the CT scanning technique.

Figure 1: Patient positioned to align implant with CT scanning direction enabling clear visualisation of the fixation region.

To use the method in clinical practice standard patient scanning procedures had to be modified (patient position needed to be modified to align the implant with scanning direction see Figure 1). Also other parts of the protocol were changed to lower the patient radiation dose.

RESULTS:

Radiolucent lines were clearly detected in the fixation region using the CT techniques (see Figure 2, left). In the laboratory setting it was possible to confirm that these radiolucent lines were in fact failed interfaces (Figure 2).

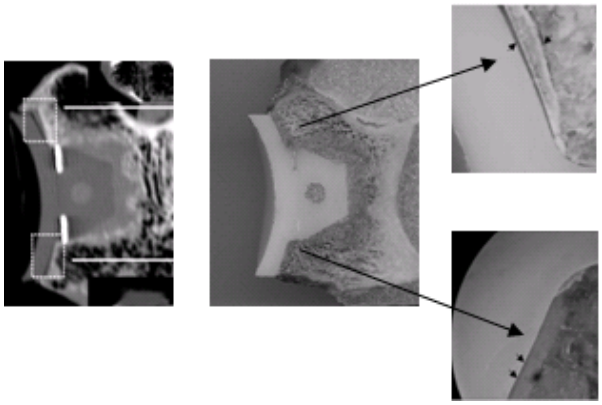

Figure 2.
Left: CT scan showing radiolucent lines both superiorly and inferiorly. Middle: Sectioned specimen. Right: Magnified superior and inferior regions showing that, consistent with the CT scan, these regions the have failed.

The modified patient position shown in Figure 1 dramatically reduced and even eliminated the metal artefacts and the fixation was clearly visible also in the clinical setting. The modified protocol also reduced the radiation dose by a factor ten compared to standard CT protocols used in shoulder surgery[4].

DISCUSSION:

The CT technique enabled detection of failure and the methodology was successfully validated in the laboratory setting. Subsequently, the technique was successfully adapted to the in-vivo setting and a large clinical study involving approximately 100 patients has commenced for the purposes of evaluating implant loosening.

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