INTRODUCTION

Mobile-bearing total knee replacements (TKR) have two articulating surfaces: a congruent surface between the polyethylene inlay and the femoral component, and a flat surface between the inlay and the tibial tray. The first surface accommodates for flexion; the latter for relative tibiofemoral rotation, and in some designs also for translation.

The concept of a mobile bearing TKR is consequently linked to the mobility of the inlay. It has been argued that the inlay may lose its mobility due to ingrowth of fibrous tissue (Lemaire 1998). Previous studies reported a loss of mobility between 0% and 50% at an average follow-up time between 1.5 and 6 years post-op (Bradley et al. 1987, Stiehl et al. 1997, Hartford et al. 2001). However, all these studies were retrospective and did not define a threshold for mobility.

Thus, inlay mobility with respect to time and the inlay motion patterns during knee flexion were analyzed in a prospective study with 60 subjects. Complete data 5 years post-op is available.

METHODS

61 mobile-bearing TKRs (SAL, Zimmer GmbH, Switzerland) in 60 patients were analyzed. The implant design allows for 6-9 mm (size dependent) inlay translation in the anteroposterior direction while the rotation is not constrained (Figure 1). In all cases the PCL was retained. The patients were followed up at 3, 12, 24 and 60 months post-op.

At each follow-up the knees were X-rayed under weight-bearing at 0°, 30°, 60° and maximal flexion. On each X-ray, the inlay translation (s) and rotation (ϕ) with respect to the tibial tray was determined by the use of an image analysis tool written in Matlab (The MathWorks, Inc.). The relative position was calculated based on the following formulae:

\[
x = \frac{2a}{b+c} p_0 - p_1
\]

\[
\varphi = \arctan \left( \frac{d - e}{d + e} t_0 \right) - \arctan \left( \frac{c - b}{c + b} p_0 \right)
\]

where \(a, b, c, d, e\) are distances measured on the X-ray as illustrated in Figure 2; and \(p_0, p_1, p_2, t_0, t_1\) are parameters that depend on the implant geometry. The accuracy of the method was determined by an experiment with a dummy and a computer simulation. It was found to be ± 0.2 mm for the translational position and ± 1.7° for the angle of rotation.

The range of inlay motion in translation (AP ROM) and in rotation (Rot. ROM) was calculated by comparing the 4 X-rays from each follow-up. An inlay was classified as mobile, if it translated more than 1 mm or rotated more than 5°. Group means where compared using one-

RESULTS

Of the 61 TKRs analyzed, a complete 3, 12, 24 and 60 month follow-up of 56 knees was available. One case was lost due to revision; three cases because the patients were deceased; and one case due to an unknown reason.

The results of the mobility analysis are summarized in Table 1. No significant change in AP ROM and Rot. ROM was found over time. At the 5 year follow-up, an average ROM in translation of 3.3 mm (0 mm - 8 mm) and an average ROM in rotation of 8.5° (2° - 20°) was observed.

At all follow-ups the inlay was classified as mobile in ≥93% of the cases. In 86% (48 of 56) of the knees the inlay was classified as mobile at every single follow-up; in the remaining 14% (8 of 56) of the knees the classification changed between follow-ups; no inlay was classified as non-mobile at every single follow-up. The majority of the inlays that displayed no translational motion were located at, or close to, the most anterior position relative to the tibial tray.

It was found that the intra-subject repeatability of the motion patterns was higher than the inter-subject repeatability. The mean RMS of the individual translation curves (0.9 mm ± 0.5 mm) was significantly lower than the overall RMS in translation (1.7 mm, \(p < 0.01\)) and the mean RMS of the individual rotation curves (2.3° ± 1.0°) was significantly lower than the overall RMS in rotation (6.1°, \(p < 0.01\)).

26% of the cases the intra-subject repeatability of inlay motion was classified as ‘high’; in 40% of the cases as ‘medium’; and in 34% of the cases as ‘low’.

DISCUSSION

In 56 mobile-bearing TKRs that were prospectively examined 3, 12, 24 and 60 months post-op, no significant change in average inlay motion or percentage of mobile inlays was found. The results do not support the hypothesis that inlay mobility is reduced due to in-growth of fibrous tissue for the time periods investigated.

Substantial variations between subjects with respect to inlay range of motion and motion patterns were found. However, the intra-subject variations were significantly lower than the inter-subject variations. Thus, each knee found its own kinematic fingerprint.

REFERENCES


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