Arthroplasty Today xxx (2017) 1–5

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Brief communication

The effect of constraint on post damage in total knee arthroplasty: posterior stabilized vs posterior stabilized constrained inserts

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A R T I C L E I N F O

Article history:
Received 20 September 2017
Received in revised form
31 October 2017
Accepted 1 November 2017
Available online xxx

Keywords:
Posterior stabilized
Posterior stabilized constrained
Surface damage
Tibial post wear
Total knee arthroplasty

A B S T R A C T

Posterior stabilized constrained (PSC) inserts are intended to provide greater varus-valgus and rotational constraint than conventional PS inserts. We determined whether the added constraint resulted in more damage to the post in PSC compared to PS inserts. Retrieved PSC inserts were matched to retrieved PS inserts from the same manufacturer according to patient age, body mass index, and length of implantation. Surface damage was visually assessed, and 3-D surface deviation from pristine was measured. Damage scores for the PSC posts were significantly greater than those of the PS posts. Surface deviation was significantly greater in the posterior and medial post regions of the PSC inserts. Based on short-term follow-up, our results suggest that added constraint is accompanied by greater polyethylene surface damage.

Introduction

The goal of total knee arthroplasty (TKA) is to obtain a well-balanced flexion-extension gap with balanced collateral ligaments. Large angular deformities, bone loss, ligamentous contracture or instability, or inability to achieve a balanced flexion and extension gap in spite of appropriate balancing techniques can warrant the use of increased constraint in primary TKA [1]. Increased constraint can be achieved with a constrained condylar knee (CCK) system by using a wider polyethylene post that closely conforms to a large femoral component box. Increased stability is achieved by limiting varus-valgus and torsional movement, the extent of which varies across different designs [2,3]. A concern with the use of CCK designs is that such a high degree of post-box constraint can impart additional loads on the bone-implant interface. Although stem extensions can mitigate this concern by distributing load to the diaphysis [4], stems are invasive, increase implant cost, increase the complexity of surgery, and are associated with leg and thigh pain [5-7].

An intermediate solution to this dilemma is a posterior stabilized constrained (PSC) insert. Such inserts have a wider post than a standard posterior stabilized (PS) insert, but a narrower and shorter post than a CCK insert, thus conforming to standard PS femoral boxes (Fig. 1). The amount of constraint varies by design; one such insert, the Optetrak Logic PSC (Exactech, Gainesville, FL), provides 3° of varus-valgus motion and 4° of rotational motion before post-box contact, as compared to the CCK insert from the same manufacturer that provides only 1.5° of varus-valgus motion and 2° of rotational motion [8]. A standard PS insert offers no varus-valgus and limited rotational constraint.

Previous research showed that increased constraint leads to increased polyethylene wear, which in turn is associated with osteolysis and component loosening [9-12]. Wear damage in PS inserts is most severe on the posterior surfaces of the post due to interaction with the cam, whereas CCK designs experience greater medial and lateral post wear damage [13]. Likewise, a recent retrieval analysis by Pang et al [14] of 18 varus-valgus constrained Genesis II inserts (Smith & Nephew, Memphis, TN) demonstrated increased overall post wear when compared to matched Genesis II

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.artd.2017.11.001.

This study has been reviewed and approved by the institutional review board.

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https://doi.org/10.1016/j.artd.2017.11.001
2352-3441/

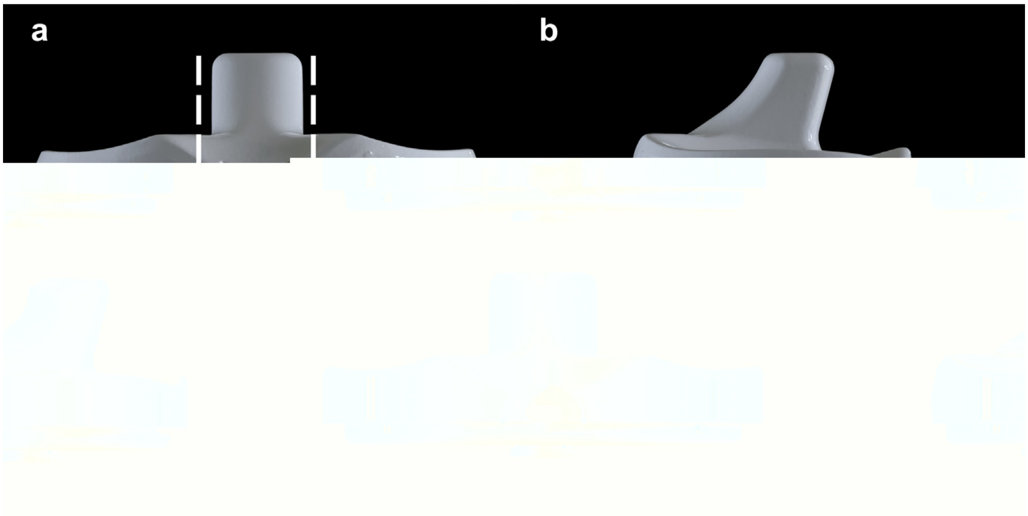

Figure 1. 3-D image demonstrating differences in the widths of the posts between the PS insert (shown in views a and b) and the PSC insert (shown in views c and d).

PS designs. However, the extent of wear in PSC polyethylene inserts has yet to be examined. We therefore designed a match-paired analysis of polyethylene inserts retrieved during revision TKA to determine the extent of additional post wear in PSC inserts when compared to PS inserts.

Material and methods

Thirty-six Optetrack Logic PSC tibial inserts were collected during revision TKAs that were performed at our institution from March 2013 to April 2016 as part of our ongoing institutional review board–approved implant retrieval program. These inserts were matched to Optetrack Logic PS tibial inserts that had been previously retrieved. Matching was performed on the basis of patient sex, age, body mass index (BMI), and the length of implantation. Due to the limited number of retrieved PSC inserts, we were unable to match on the basis of insert size or thickness. Demographic data were obtained from clinical records, and the indication for revision surgery was determined from operative notes (Table 1).

Radiographic assessment

Initial postoperative weight-bearing anteroposterior and lateral digital radiographs were reviewed to assess component alignment. Measurements were made using methods described by Meneghini et al [15]. The position of the femoral component was measured with respect to a 5° valgus cut angle. Tibial components were measured in relation to a perpendicular tibial cut. Valgus component alignment was expressed as a positive value, and varus component alignment was expressed as a negative value. Lateral images were assessed for femoral component flexion with respect to the intramedullary axis and for tibial component posterior slope.

Visual damage assessment

To visually assess surface damage to the polyethylene inserts, well-established subjective methods were used to assign damage scores [16]. The articulating surfaces of the inserts were divided into 14 regions, and the backside of the inserts was divided into 4 regions (Fig. 2). Two independent observers (JK, LW), blinded to the clinical, demographic, and radiographic data, visually inspected each region under stereo light microscopy at 10× magnification. Each region was assessed for 7 damage modes: scratching, pitting, burnishing, abrasion, delamination, surface deformation, and third-body debris. Damage sustained during surgical removal was disregarded. Each damage mode was assigned a score of 0 to 3 based on the severity and extent of the damage. This gave a maximum possible damage score of 378 (294 for the articular surface and 84 for the backside). The difference in total damage scores was never greater than 10 points between the 2 observers; therefore, a third observer was not used. The mean value among observers was used for analysis.

Surface dimensional changes

Surface dimensional changes were quantified using a laser scanning method described by Stoner et al [17]. This method determines the dimensional changes in the surface geometry of the inserts compared either to the design drawing for the part or to a pristine insert of the same size as the retrieved insert. The dimensional changes likely resulted from both permanent deformation of the insert and loss of material (wear).

The 36 matched pairs of inserts were coated with aerosol talc and scanned using a 3-D laser scanner (Range 7; Konica Minolta, Inc., Tokyo, Japan). To obtain a scan of the complete surface of each insert, 20 scans at different viewing angles were performed. The data analysis was performed using Geomagic Studio software (Morrisville, MC).

Reconstructed 3-D models were precisely aligned with either manufacturer-provided computer-aided design (CAD) models

Table 1
Patient demographic data.

Variable	PSC insert	PS insert	*P* value
Number	36	36	N/A
Percentage of females	52.5%	40.0%	.19
Age at index surgery (y)	66.1 ± 6.8	63.7 ± 7.7	.13
Body mass index (kg/m^2)	30 ± 6.8	29.7 ± 5.2	.72
Length of implantation (mo)	11.2 ± 10.4	13.9 ± 9.4	.13

N/A, not applicable.
Data are presented as mean ± standard deviation; comparisons were made using Student *t*-tests for continuous variables and chi-square tests for categorical variables.