The influence of leg length difference on clinical outcome after revision TKA

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Background: The purpose of this paper was to document the incidence of leg length changes after revision total knee arthroplasty (TKA) and its effect on clinical outcome.

Methods: Leg length difference (LLD) was prospectively measured in 85 patients using digital standing full leg radiography before and after revision TKA. Additionally the patient’s subjective perception of LLD was assessed postoperatively. Linear regression models were used to study the correlation between each of these parameters and the clinical outcome after 1 year. Clinical outcome was evaluated by means of the Knee Society Score (KSS).

Results: Revision TKA resulted on average in an increased leg length of 5.3 mm. Sixty-five legs (76%) were lengthened with the procedure, 17 (20%) were shortened and three (4%) remained of identical length. Increased leg length after revision was positively correlated with clinical outcome at 3 months (Spearman r = 0.22, p = 0.044) and 1 year (Spearman r = 0.26, p = 0.027). The evidence for this correlation remained after correction for age, gender and diagnosis (p = 0.012). The most important contributors to improved clinical outcome scores were improved pain score (Spearman r = 0.19, p = 0.09) and increased stability (Spearman r = 0.13, p = 0.24), rather than range of motion (Spearman r = - 0.02, p = 0.85).

Conclusions: The results from our work indicate that revision TKA tends to lengthen the leg by approximately 5 mm. Contrary to what might be expected, leg lengthening after revision TKA is correlated with improved clinical outcome.

Level of evidence: Level 2b.

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1. Introduction

Unlike for primary hip arthroplasty, leg length restoration is generally not considered an issue during primary TKA. The reason for this is that contrary to the hip, primary knee arthroplasty is based upon the principles of matched resection. The damaged surface is replaced by prosthetic components with an equal thickness of the removed and eroded parts of the joint. The knee joint is thus restored within the constraints of the ligamentous and capsular structures surrounding the knee [1].

The situation is however different in revision TKA on two fundamental aspects. First, removal of the components during revision is inevitably associated with damage to the underlying bone. It therefore becomes uncertain for the surgeon how much bone has been lost or resected, and how much should therefore be restored. Secondly, the surrounding soft tissues can no longer be considered normal in the revision situation. Soft tissue tension may therefore inadvertently influence the surgeon as to how much the prosthetic components should be built up in order to obtain a stable joint with appropriate peri-articular soft tissue tension [2]. In theory, both of these factors could therefore lead to over- or under-correction of leg length during revision TKA. Whether such iatrogenic lengthening or shortening really occurs in surgical practice is however unclear, and to our knowledge also no data exist on its potential influence on clinical outcome. The aim of our study was therefore to investigate the relation between LLD after revision TKA and clinical outcome.

2. Patients

After approval by the ethical commission of our institution, a monocentric case series study was conducted in 85 patients who underwent revision TKA using the Legion revision knee system (Smith and Nephew, Memphis). These patients were recruited from our revision database which included the data of all 287 revision TKAs operated between January 2007 and December 2010 at our institution. Of these 287 revisions, only the patients who received a Legion revision prosthesis of Smith and Nephew were included in this study. One hundred and forty-four patients received this type of prosthesis. All revisions were one-stage revisions. Only patients with a first revision were included. Indications for revision were aseptic loosening (42 patients), infection (13 patients), component malposition (13 patients), persisting pain (10 patients), instability (five patients) and Polyethylene wear (two patients). Patients with one or more of the following criteria were excluded from the
analysis: retention of either the primary tibial or femoral component during revision, surgery of the contralateral limb during follow-up, a postoperative flexion contracture >5°, inadequate bilateral full leg radiographs or incomplete pre-operative or final follow-up data at 1 year post surgery.

Of the 144 patients who received a Legion revision prosthesis, 27 were excluded because they had surgery less than 1 year ago and follow-up data up to 1 year postoperative were not available. Twelve patients were lost to follow up. Eleven were excluded because they had a cement spacer preoperatively and no adequate full leg radiographs were taken. Six were excluded because they had surgery at the contralateral limb during follow up. Three patients were excluded for retention of one of the components during surgery. At one year postoperatively 85 patients were available for follow up with all data available. Of the 85 patients included in this study, 53 received a posterior stabilized insert whereas 30 patients received a constrained insert.

3. Methods

All surgeries were performed by one of the three surgeons of our knee arthroplasty team.

The length of the operated and the non-operated limb was measured using calibrated digital full leg radiographs. Radiographs were taken immediately prior to revision and at 3 weeks postoperatively and were obtained with the patient standing barefoot, the knees in maximal extension and the feet together in the “stand at attention” position while the patellae were oriented forward. The X-ray beam was centered on the knee joint with the radiography tube at a distance of 305 cm. Three 350 × 430 mm cassettes were placed immediately behind the subject and the AGFA MIMOSA VIPS 1.3.00 software package was used for digital stitching. A setting of 500 mA and a kilovoltage of 75 kV was used as the standard and individually adapted when necessary. The whole pelvis was included in the radiographs and the gonads were always shielded. All radiographs were calibrated and all measurements were performed by the same person (SM) using the AGFA PACS software package. Leg length was measured from the highest point of the femoral head to the medial malleolus. Figs. 1 and 2 show standing full leg radiographs pre-and postoperatively with measurement technique. The same observer measured twice the leg length (both legs) pre- and postoperatively. Differences between the two replications and 95% limits of agreement were visualized using Bland–Altman plots [3]. The intra-class correlation for a single value (ICC) and 95% confidence interval (CI) is obtained from a 2-way random model, using the absolute agreement definition [4]; this corresponds to the ICC(2.1) in the Shrout & Fleiss terminology [5]. The within-subject standard deviation (SD) from this model is expressed relative to the mean abductor moment level, yielding the within-subject coefficient of variation (WSCV).

Clinical and functional outcome assessment was performed using the Knee Society Clinical Rating System prior to the intervention and at 3 months and 1 year postoperatively [6]. Patients were stratified based upon a questionnaire on whether they thought their legs were of the same length after the revision or not. Those patients who indicated that their legs were of different length were further questioned whether they wore a shoe raise or used any other compensatory method, and whether they had experienced increased low back symptoms since the revision procedure. Every question was responded with a yes or no answer.

Statistical analysis was performed by the Biostatistical Centre of the School of Public Health of the Catholic University Leuven, using the SAS statistical package version 9.2 (SAS Institute, Cary, NC). Linear regression models were used to study the correlation between leg length differences and clinical outcome, and were verified after correction for age, gender, and indication for revision. Mann–Whitney-U tests were used to determine the relation between the perceived leg length differences and radiographic measured differences. General linear models for repeated measures were used to evaluate leg length as a function of time (pre-post) and side (operated or not). A direct likelihood approach was adopted using an unstructured covariance matrix. P-values smaller than 5% were considered significant.

Fig. 1. Preoperative standing full leg radiograph in a woman with bilateral TKA and loosening of the right tibial component. Measurement technique is shown.
Leg length increased on average by 5.3 mm (9.6 SD) after revision TKA. 65 legs (76%) were lengthened with the procedure, 17 (20%) were shortened and 3 legs (4%) remained of identical length. After surgery the operated leg was on average 3.8 mm (10.8 SD) longer than the contralateral side (p=0.001). Postoperative leg length difference ranged from 24 mm shorter to 35 mm longer. After revision, 53 of the operated legs (62%) were longer than the contralateral side, and 32 (38%) were shorter or equal in length.

In 20 patients, no augments were used. Four patients received a tibial augment where 61 patients were lengthened with distal femoral augments or a combination of distal and posterior femoral augments. Intra-observer variability was assessed in a subset of the data (20 patients). There is an extreme high level of intra-observer reliability. The ICC equals 0.998. The within-subject SD (or standard error of measurement) equals 7.4 mm, leading to a WSCV of only 0.84% and 95% limits of agreement in the Bland–Altman plot of −7.5 mm to 6.5 mm. The latter is the range where 95% of the differences between replicated measurements by the same observer are expected to fall in.

Increased leg length after revision was positively correlated with clinical outcome at 3 months (Spearman r = 0.22, p = 0.044) and 1 year (Spearman r = 0.26, p = 0.027). The evidence for this correlation remained after correction for age, gender and diagnosis (p = 0.012). The most important contributors to improvement of KSS scores were improved pain score (Spearman r = 0.19, p = 0.09) and increased stability (Spearman r = 0.13, p = 0.24), rather than range of motion (Spearman r = −0.02, p = 0.85).

The total Knee Society score improved from an average of 82 (28.8 SD) preoperatively to 123.5 (37.2 SD) at 1 year (p = 0.001), the average clinical score improved from an average of 47.7 (13.3 SD) preoperatively to 70.6 (18.6 SD) at 1 year (p = 0.001), and the function score improved from an average of 34.3 (22.6 SD) preoperatively to 52.9 (24.2 SD) at 1 year (p = 0.001). Range of motion improved from an average of 88 (30.5 SD) degrees preoperatively to 109 (14.8 SD) degrees at 1 year (p = 0.001). Twenty-one patients (25%) perceived a leg length difference following the procedure and in each of these the operated leg length was longer than the contralateral side. No correlation was found between subjectively perceived leg length difference and overall clinical or functional outcome at 3 months (p = 0.46) or 1 year (p = 0.72). Patients with a perceived leg lengthening had however significantly better pain scores at 1 year than patients who did not perceive a leg length difference: 34 (12.5 SD) versus 26 (14.7 SD) respectively (p = 0.04). 7 (33%) of the patients with perceived leg length difference wore a shoe insert on the other leg for compensation, but none of them had increased back symptoms since the procedure.

Fig. 2. Postoperative standing full leg radiograph of the woman in Fig. 1 with a revision prosthesis on the right side. Measurement technique is shown.

5. Discussion

The most important finding from our work is that in the majority of cases leg length was increased after revision TKA. Patients should be well informed of this fact prior to surgery. We believe that damage to the capsuloligamentous envelope and underlying bone drives the surgeon to build up the prosthesis in order to obtain a stable joint. Our study shows that this increased leg length is correlated with improved clinical outcome. These findings may at first sight seem surprising, since iatrogenic leg lengthening during surgery is usually not considered as beneficial. In fact, and although this is still debated, the general belief amongst hip surgeons is that iatrogenic leg lengthening during hip arthroplasty should be avoided [7–12].

Konyves et al. and Wylde et al. concluded that leg length difference and patients’ perception of leg length difference both have a negative influence on functional outcome scores at 3 months and 1 year following primary total hip arthroplasty (THA). Using different outcome scores however, White et al. concluded that leg length difference following primary total hip arthroplasty had no effect on outcome scores or patient satisfaction. Despite this lack of consensus, Maloney noted that leg lengthening is one of the major causes of litigation following total hip arthroplasty, and that even small leg length discrepancies are a source of patient dissatisfaction [13]. Our study demonstrated that leg lengthening after revision TKA leads to the contrary effect as after hip arthroplasty. In our patients leg lengthening was positively correlated with better clinical outcome, mainly due to improved pain scores and better stability, rather than improved range of motion. We believe there is a reasonable explanation for this finding. Unlike for primary TKA, several technical issues indeed exist during revision TKA which could compromise correct leg length restoration. Removal of the components during revision TKA inevitably leads to damage of the underlying bone, and it is not always clear for the surgeon how much the prosthetic components should be built-up to correctly compensate for this. The same is true for the
periprosthetic soft tissue sleeve, which may have been altered during the primary or revision procedure, thereby inadvertently influencing the surgeon as to how much the prosthetic components should be built up in order to obtain a stable joint with appropriate peri-articular soft tissue tension. We believe that it is indeed the altered soft tissue status with attenuation or secondary damage to the capsuloligamentous envelope which frequently drives the surgeon towards the use of thicker metallic components or a thicker polyethylene insert in order to balance the joint within the surrounding soft tissue sleeve, thereby increasing total leg length. In our study leg length increased on average by 5.3 mm from −1.5 mm preoperative to +3.8 mm postoperatively, and 76% of the legs were lengthened with the procedure. Such lengthening was indeed positively correlated with improved clinical outcome, mainly due to less pain and better stability. To our knowledge this is the first paper that studied leg length alteration after revision TKA. Regarding primary TKA we could only find one paper that looked into the relationship between leg length difference and functional outcome. Vaidya et al. studied leg length difference in a group of patients with bilateral varus osteoarthritis of the knee, of which half of the patients underwent unilateral TKA and the other half bilateral TKA [14]. A statistically significant negative correlation was found between leg length discrepancy and functional outcome in the unilateral group, whereas no correlation was found in the bilateral group. The authors therefore concluded that leg length discrepancy negatively affected functional outcome after TKA in patients with bilateral varus deformity when undergoing surgery of only one knee. The study therefore suggested that it is not the lengthening per se that caused the inferior outcome, but rather the discrepancy in length with the contralateral (unoperated) leg. In the group where the contralateral leg was also operated, leg length discrepancy was better restored and had no longer an effect on functional outcome. Since this study focuses on functional Knee Society (KSS) after primary TKA and we mainly focused on clinical KSS after revision TKA, comparison between the two studies is difficult.

Our study has a number of limitations. One single observer performed all the measurements, and obviously the results of the measurements may be influenced by the accuracy of the investigator. However, the fact that a single observer was used is at the same time an assurance of consistency of method and scrutiny. It could however have introduced a systematic bias. Since we have measured the functional leg length instead of anatomical leg length, anatomical leg length differences might be included in our measurements. This might influence our results. Postoperative radiographs were taken three weeks following surgery. Hauschild et al. however, state that when taking postoperative radiographs, results might improve when the radiographs are delayed to a time when more patients achieve full or near-full extension and are able to bear full weight, leading to more valid radiographs [15]. Radiographic measurements can be quite accurate in controlled settings. Perhaps a better way to measure leg length difference is by intra-operative navigation techniques [16]. Our study focused on total leg length and did not include analysis of joint line position. It is important to note that leg length restoration and joint line restoration are two separate entities.

Leg length alterations after revision TKA may occur independent of joint line position, at least when measured according to the classical reference methods that thereto exist. Indeed, it is very well possible to increase leg length while maintaining the same joint line level as measured using the Insall–Salvati, Blackburne Peel or Caton–Deschamps index [17–20]. The effect of leg lengthening after revision TKA should therefore be well differentiated from the effect of eventual joint line restoration, which has been studied before by several authors [19–22]. Most of these have noted a tendency towards joint line elevation after revision TKA, and have therefore suggested the systematic use of distal femoral augments to avoid this [22–24]. Since we did not evaluate the influence of joint line elevation on clinical outcome, no statements can be made regarding this subject.

6. Conflict of interest

We, the authors conclude that all the material within has not been and will not be submitted for publication elsewhere except as an abstract.

References


