The Knee 23 (2016) 517–522

Contents lists available at ScienceDirect

The Knee

The influence of posterior tibial slope changes on joint gap and range of motion in unicompartmental knee arthroplasty

Koji Takayama [a], Tomoyuki Matsumoto [a,*], Hirotsugu Muratsu [b], Kazunari Ishida [c], Daisuke Araki [a], Takehiko Matsushita [a], Ryosuke Kuroda [a], Masahiro Kurosaka [a]

[a] Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Hyogo, Japan
[b] Department of Orthopaedic Surgery, Steel Memorial Hirohata Hospital, Himeji, Hyogo, Japan
[c] Department of Orthopaedic Surgery, Kobe Kaisei Hospital, Kobe, Hyogo, Japan

ARTICLE INFO

Article history:
Received 5 October 2015
Received in revised form 5 January 2016
Accepted 9 January 2016

Keywords:
Unicompartmental knee arthroplasty
Tibial slope
Tensor
Gap

ABSTRACT

Background: The effect of posterior slope on joint gap in unicompartmental knee arthroplasty (UKA) has yet to be quantified. The purpose of this study was to quantify the effect of the tibial slope on the joint component gap and postoperative range of motion in UKA.
Methods: Forty consecutive patients were prospectively enrolled. The correlation between the tibial slope changes and the component gap, the component gap difference between flexion angles, the postoperative extension or flexion angles was examined. The correlation of joint looseness with tibial slope changes and postoperative extension angle was also examined.
Results: Increased tibial slope positively correlated with the differences between the component gap at 90° and 10°, 120° and 10°, or 135° and 10° knee flexion angle. Although tibial slope change did not affect postoperative flexion angle, increased tibial slope reduced postoperative extension angle. Moreover, increased tibial slope resulted in decreased joint looseness during 10° of knee flexion and decreased joint looseness during 10° of knee flexion resulted in reduced postoperative extension angle.
Conclusions: Increased tibial slope resulted in tight component gap at knee extension compared with that at knee flexion. Furthermore, tight component gap at extension lead to decreased postoperative extension angle. These results indicate that an individual anatomical tibial slope should be considered when tibial sagittal osteotomy was performed and increasing tibial slope should be avoided to achieve full extension angle after UKA.
Level of evidence: II.

1. Introduction

Unicompartmental knee arthroplasty (UKA) is a surgical alternative for patients with isolated medial osteoarthritis and osteonecrosis. The advantages of UKA over total knee arthroplasty (TKA) include reduced perioperative morbidity, reduced blood loss, shorter rehabilitation, and increased postoperative range of motion (ROM) [1–4]. Although 10-year survival rates greater than 90% for metal-backed tibial components have been reported [5,6], several factors have been associated with UKA success, including correct patient selection and accurate osteotomy and soft tissue tension, which are all essential for good clinical outcomes and survival of the implant [7,8].

The tibial slope is an important factor associated with knee kinematics and relates to failure of the implant in UKA [9,10]. It has been reported that angles >7° of tibial slope should be avoided to prevent early failure [11]. On the other hand, variability in the tibial slope has been reported. Nearly half of preoperative tibial slopes have been reported to be >7°, and a routine target of tibial slope of approximately seven degrees may fail to recreate a patient's native anatomy in a large percentage of patients [12]. A number of studies suggested that tibial slope changes influenced on the flexion gap and postoperative range of motion in cruciate-retaining TKA [13–17]. The altered tibial slope might influence soft tissue tension in UKA; however, few studies have reported that altered tibial slope affects soft tissue tension in UKA.

Recently, a tensor designed to assess soft tissue tension during UKA was developed [18–21]. An intraoperative joint gap can be measured with this tensor throughout the ROM under various distraction forces. Using this tensor, several studies have reported the difference in intraoperative joint gap kinematics between UKA and TKA [18], the correlation between the component joint gap after the femoral component was in place and the original joint gap before femoral osteotomy [19], the positive correlation of joint gap with insert thickness [20], and the

Abbreviations: UKA, unicompartmental knee arthroplasty; TKA, total knee arthroplasty; ROM, range of motion; HKA, hip–knee–ankle angle; SD, standard deviation; KSKS, Knee Society Knee Score; KSFS, Knee Society Function Score.

* Corresponding author at: Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, 7-5-1, Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan. Tel.: +81 78 382 5985; fax: +81 78 351 6944.
E-mail address: matsun@m4.dion.ne.jp (T. Matsumoto).

http://dx.doi.org/10.1016/j.knee.2016.01.003
0968-0160/

negative correlation between the joint gap in flexion and postoperative flexion angle [21]. To our knowledge, the effect of posterior slope on joint gap in UKA has yet to be quantified. The purpose of this study was to quantify the effect of the tibial slope on the joint component gap in UKA. Furthermore, the correlation between the tibial slope and postoperative clinical outcomes was examined.

2. Methods

The study was approved by the institutional review board (No. 1510), and informed consent was obtained from all patients. Forty consecutive patients were prospectively enrolled. Twenty-two women and 18 men who were diagnosed with either isolated medial compartmental osteoarthritis (18 cases) or spontaneous osteonecrosis of the knee (22 cases) during 2011–2013 were eventually included in this study. The surgical criteria of UKA included a radiographic diagnosis of isolated medial compartmental osteoarthritis or idiopathic osteonecrosis with fixed flexion deformity of <10°, an active ROM of >90°, and a varus deformity of <15°. MR images were also performed before surgery to confirm intact ACL and intact articular surface of paterllofemoral (PF) and lateral compartment. Two senior doctors, each with >10 years of experience performing knee arthroplasty, performed the surgeries using the medial Zimmer Unicompartmental High Flex Knee System (Zimmer Inc., Warsaw, IN, USA).

After inflating the tourniquet to 280 mm Hg, a limited medial parapatellar approach was employed with an incision from the superomedial border of the patella to 1.5 cm distal to the medial tibia plateau articular surface. Following observation of the intact ACL and intact articular surface of PF and lateral compartments, minimal soft tissue release of the medial structures and osteophyte removal was performed. A proximal tibial osteotomy was then performed using an extramedullary alignment guide after ensuring that the bone cut was made perpendicular to the mechanical axis in the coronal plane and with posterior inclination along the sagittal plane of the tibia, with reference to an individual anatomical tibial slope. Following the tibial osteotomy, a distal femoral osteotomy was performed using a spacer block, while referring to the surface of the proximal tibial cut. Femoral rotation was adjusted to the mechanical axis of the tibia using the spacer block [1], and the remaining osteotomies of the femur were performed.

The UKA tensor consists of an upper plate, a lower platform plate with a spike, and an extra-articular main body. The two plates are placed at the medial compartment of the knee. This tensor enables surgeons to intraoperatively assess the component gap of the joint after femoral component placement throughout the ROM and under various distraction forces. Design details and the methodology of the UKA tensor have been reported previously [18]. Following the femoral bony resection and with the femoral trial prosthesis in place, the tensor was fitted with its lower platform fixed to the proximal tibia and the upper plate fitted to the medial femoral component. During the measurement, the medial parapatellar arthrotomy was temporarily repaired by applying stitches proximally to the connection arm of the tensor. The thigh and knee were aligned in the sagittal plane to eliminate the external load on the knee. The joint distraction forces were preloaded several times until the joint gap remained constant in order to reduce the error that may result from creep elongation in the surrounding soft tissue. The joint gap (measured in mm), defined as the component gap between the medial tibial osteotomy surface and the femoral trial prosthesis, was measured. The component gap was measured at 0°, 10°, 30°, 45°, 60°, 90°, 120°, and 135° of knee flexion with distraction forces of 20 kg (Fig. 1).

Preoperative and postoperative coronal HKA angles and posterior tibial slope were measured by using long leg standing radiographs. The posterior tibial slope was measured with reference to the sagittal axis, which was defined as the line connecting the midpoints of the medial tibia plateau and the tibia plafond (Fig. 2) [22]. Preoperative and postoperative Knee Society Knee Score (KSKS) and Knee Society Function Score (KSFS) were used for clinical evaluation and knee extension and flexion angles were measured by using a two-arm goniometer with the patient in the supine position at the latest follow-up visit. The correlation between the postoperative tibial slope and the component gap, the component gap difference between flexion angles, the postoperative extension or flexion angles, the KSKS, or the KSFS was examined. The correlation between the amount of tibial slope changes before and after surgery with the component gap, the component gap differences between flexion angles, the postoperative extension or flexion angles, the KSKS, or the KSFS was also examined. Joint looseness, which was defined as joint component gap under traction with 20 kg weight minus polyethylene insert thickness, was calculated at each knee flexion angle. The correlation of joint looseness with tibial slope changes and postoperative extension angle was also examined.

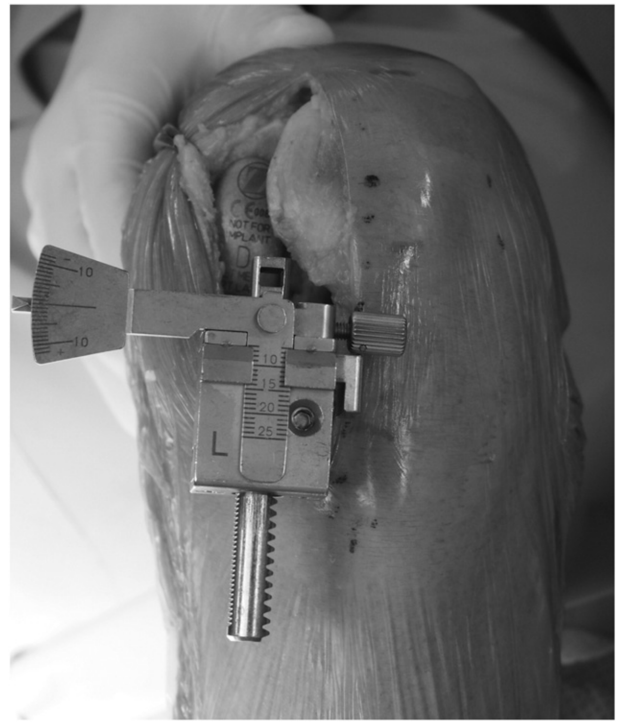

Fig. 1. Unicompartmental knee arthroplasty tensor. The intraoperative component gap after femoral component placement was examined with the unicompartmental knee arthroplasty (UKA) tensor throughout varying ranges of motion with various distraction forces.

2.1. Statistical analyses

The data are expressed as means ± SD. The relationship between tibial slope, soft tissue parameters, and postoperative clinical outcomes were analyzed using Pearson's correlation coefficient and simple linear regression analysis. Data analyses were performed using PASW Statistics 21 (SPSS, Chicago, IL). The sample size calculation was also performed using G*Power 3 (Heinrich Heine Universität Düsseldorf, Germany). By our calculation, a sample of 29 patients was the minimum required to observe a moderate correlation between the posterior slope and postoperative knee extension or flexion angle with a type I error (α) of 0.05, a power ($1-\beta$) of 0.80 and a correlation ρ H1 of 0.5.

3. Results

The mean ± standard deviation (SD) age of the patients at the time of operation was 72.4 ± 8.3 years. The mean preoperative hip–knee–ankle (HKA) angle was 6.9° ± 3.3° varus, tibial slope angle was 10.2° ± 2.3°, knee extension angle was −4.9° ± 1.1°, knee flexion angle was 129.8° ± 9.2°, KSKS was 45.4 ± 5.4, and KSFS was 46.3 ± 7.9 (Table 1).