The Adjustment of Component Gap during Posterior Stabilized Total Knee Arthroplasty using Femoral Posterior Condylar Pre-cut Technique

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INTRODUCTION: During total knee arthroplasty (TKA), adjusting the gap lengths to ensure equal lengths in both extension and flexion is important for achieving successful outcomes. The restoration of equal extension and flexion gaps is a widely accepted surgical goal of TKA as it reduces the incidence of stiffness and instability. In TKA, these spaces are estimated as the extension and flexion gaps after bone resection. However, gaps without the trial femoral component (bone gaps) after bone resection often differ from those after setting the trial femoral components (component gaps; CGs). Therefore, preparation for setting the femoral component using a "pre-cut trial component" (PCT) before the final cutting of the posterior femoral condyle is useful [1]. However, the usual pre-cut technique is only used for cruciate-retaining (CR) TKA. Thus, we designed a novel PS PCT to reproduce the cam structure for posterior-stabilized (PS) TKA. The cam structure occupies a large portion of the intercondylar notch and tenses the soft tissues around the intercondylar notch, which may affect the CGs. Hence, the purpose of this study was to clarify whether the cam structure of PS TKA affects the CGs and whether the pre-cut technique could be useful for PS TKA.

METHODS: Between July 2020 and May 2023, 43 patients (51 knees) included osteoarthritis (OA) (49 knees) and rheumatoid arthritis (2 knees), the mean age 75.0 ± 9.1 years (mean ± SD) that underwent primary PS TKA (Vanguard PSRP®: Zimmer Biomet) were enrolled in this study. This study was approved by the Institutional Review Board in this hospital. Informed consent was obtained from each patient. The femoral component of the Vanguard PSRP® PS TKA system is composed of a 9-mm-thick distal part and a 9-mm-thick posterior part. The PCT for CR TKA is composed of a 9-mm-thick distal part and a 4-mm-thick posterior part and lacks an anterior part of femoral component, and the PCT for PS TKA is composed of same thickness of distal and posterior part with a cam structure (Fig. 1a). First, the distal femur and proximal tibia were cut to create the extension gap. The rotation of the femoral component was set at 0°–6° to the femoral posterior condylar line, with reference to the femoral surgical transepicondylar axis by preoperative CT. Next, a 4-mm pre-cut was made from the lateral posterior condylar line of the femoral posterior condyle for use with the CR and PS PCTs of the femur (Fig.1B-a, 1B-b). Once all of osteophytes were removed, the PCTs were attached to the femur, and the CGs by CR and PS PCTs were checked at 0˚ and 90˚ of knee flexion using a spacer block, and the CGs attached when CR PCT were compared with the CGs attached when PS PCT. When the extension CGs with PS PCT became narrow, the release of the intercondylar notch capsule was performed (Fig. 1C-a). When the extension CGs were narrow even after the release of the intercondylar notch capsule, a posteromedical vertical capsulotomy was performed to enlarge the extension CGs (Fig. 1C-b) (2). Then, in cases in which the flexion gaps were larger than the extension CGs, small additional resection of the posterior femoral condyle was performed to decrease the flexion gaps (Fig. 1B-c). Final CGs with the usual trial femoral components were compared with CGs in PS PCT at 0˚ and 90˚ of knee flexion (Fig. 1B-d).

RESULTS: The component gaps using CR and PS PCTs were 10.1 ± 1.2 mm and 9.7 ± 1.4 mm at 0˚, 10.6 ± 0.93 mm and 10.7 ± 0.86 mm at 90˚, respectively (Fig. 2A). The CG in extension with PS PCT was significantly smaller than that in extension CG with CR PCT. Release of the posterior capsule of the femoral intercondylar notch was performed in 34 knees (67%), and additionally, the posteromedical vertical capsulotomy was performed in 15 knees (15%), and the extension gaps significantly increased by 1.7 ± 0.90 mm (increasing 1.0 ± 0.067 mm by the release of the posterior capsule of the femoral intercondylar notch, and additionally increasing 1.5 ± 0.24 mm by posteromedical vertical capsulotomy), compared with those before release in PS PCT (Fig. 2B). The gap control amount was average 0 ± 0.35 mm, and the additional cutting of the posterior femoral condyle to adjust the gap lengths to ensure equal lengths in both extension and flexion were 5 mm (gap control 0 mm; 45 knees), 4 mm (gap control posteriorly 1 mm; 3 knees), and 6 mm (gap control anteriorly 1 mm; 3 knees). The final CGs using trial components at 0˚ and 90˚ knee flexion were 10.8 ± 0.87 mm and 10.9 ± 0.79 mm, and were not significantly changed compared with the CGs at 0˚ and the estimated CGs after gap control at 90˚ knee flexion in PS PCT, respectively (Fig. 3).

DISCUSSION: The extension gaps with PS PCT were decreased comparing with that with CR PCT, and were increased by an average 1.7 mm by releasing of the soft tissue around the intercondylar notch and posterior capsule. The position of the cam in the femoral component depends on the shape of the femoral component as determined by each manufacture. The cam occupies a large part of intercondylar notch, and the soft tissue around the intercondylar notch is subjected to tension at knee extension, therefore, the cam of the PS femoral component affected the only extension gap.

The flexion gaps are usually increased by resection of the PCL (3); therefore, the gap control at the 90˚ of knee flexion is especially needed during the PS TKA. However, only 3 knees were flexion gap controlled posteriorly in this series. The reason might be that the superficial medial collateral ligament was not be released. In any case, the final CGs at extension and flexion were well reproduced by putting on the PS PCT after pre-cut of the posterior femur, therefore, the PS PCT is a useful item that can estimate the component gaps before the final osteotomy of the femur, and it is possible to adjust the CGs in extension and flexion to create the stable knee during PS TKA.

SIGNIFICANCE: The cam structure of the PS femoral component affected the extension gap. The pre-cut system for PS TKA is a useful item that can reproduce the CGs before the final osteotomy of the femur.

REFERENCES: 1. Kaneyama et al., J Knee Surg. 2019, 32 (10): 1001-1007; 2. Yoshino et al., Knee Surg. Sports Traumatol., 2023, 31 (4): 1247-1353; 3. Kadoya et al., Clin. Orthop. and Relat. Res. 2001, 391: 210-217

Fig. 1

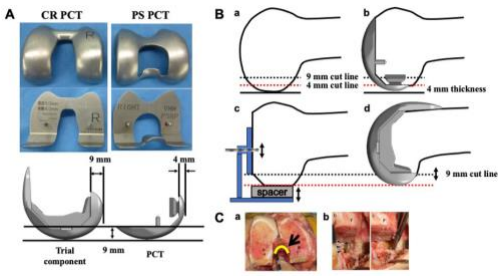

Fig. 2

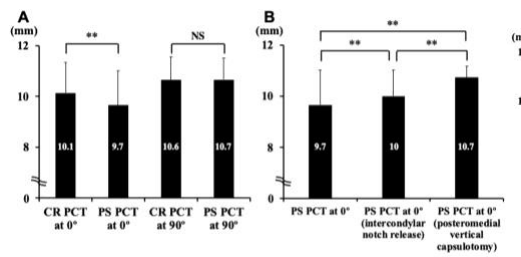

Fig. 3