Comparative Study of Two Techniques for Ligament Balancing in Total Knee Arthroplasty for Severe Varus Knee: Medial Soft Tissue Release vs. Bony Resection of Proximal Medial Tibia

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Purpose: Bony resection of the proximal medial tibia, an alternative technique for soft tissue balancing in total knee arthroplasty (TKA), was compared to the conventional medial soft tissue release technique.

Materials and Methods: From June 2005 to June 2007, we performed 40 TKA in 27 patients with ≥10° tibio-femoral varus deformity. The conventional, medial soft tissue release technique was applied in 20 cases and bony resection of proximal medial tibia in the other 20 cases (vertical osteotomy group). Total operation time, knee range of motion (ROM), hospital for special surgery (HSS) scores, and tibio-femoral medial-lateral gap ratio in 0°, 90°, and 130° flexion at postoperative 6 months were compared between the groups.

Results: The total operation time was shorter in the vertical osteotomy group. Tibio-femoral medial-lateral gap ratio in 130° flexion was closer to 1 in the vertical osteotomy group (p=0.000). There was no significant difference in the ROM, HSS score, or tibio-femoral medial-lateral gap ratio in 0° and 90° flexion at postoperative 6 months.

Conclusions: In severe varus knees, bony resection of proximal medial tibia can be considered as an alternative technique, in order to decrease total operation time and to obtain medial-lateral, soft-tissue balance in deep flexion.

Keywords: Knee, Varus deformity, Total knee arthroplasty, Bony resection, Proximal medial tibia

Introduction

Total knee arthroplasty (TKA) has been frequently performed for severe degenerative arthritis in senior patients. Unfortunately, TKA can be technically challenging in knees with profound varus deformity when it is combined with medial soft tissue contracture and lateral soft tissue laxity. Ligament balancing has been considered essential to the success of a TKA and release of the contracted medial soft tissues from the tibial attachment site has been widely performed to balance the medial-lateral soft tissue tension. However, this technique may result in an intraoperative rupture in the presence of soft tissue contracture or adhesion or medial instability of the knee. Minimal soft tissue release followed by resection of the proximal medial tibia along the longitudinal axis of the tibia can be considered as an alternative. This technique is expected to be a safer option that would reduce the incidence of complications, such as medial collateral ligament (MCL) rupture, by allowing minimal release of the superficial layer of the MCL from the tibial attachment site. In spite of this, there has been no domestic study on this technique.

The purpose of this study was to compare the results of TKA using the conventional medial soft tissue release and longitudinal bony resection of the proximal medial tibia with minimal soft tissue release in severe varus knees.
Materials and Methods

Of the patients who underwent TKA performed by the same surgeon at our institution between June 2005 and June 2007, 27 patients (40 cases) with ≥10° tibio-femoral varus deformity on the preoperative whole leg standing anteroposterior (AP) view (Fig. 1) were included in this prospective randomized controlled study. All study participants were female with a mean age of 71.5 years (range, 62 to 83 years). The mean preoperative, anatomical tibio-femoral axis was varus 13.3° (range, 11° to 19°) (Table 1).

TKA was performed using a posterior-stabilized type prosthesis in all cases. For ligament balancing, the conventional medial soft tissue release was performed in 20 cases (medial release group). In the remaining 20 cases (vertical osteotomy group), a vertical osteotomy for one size smaller tibial component was performed using an osteotome in the proximal medial tibia for ligament balancing (Fig. 2).

There was no statistically significant difference in age and preoperative varus deformity angle, range of motion (ROM), and hospital for special surgery (HSS) score between the groups. In the medial release group, the knee joint was exposed using a midvastus approach and medial soft tissue was released up to 1 cm distally from the subperiosteal layer of the joint capsular insertion site, on the proximal tibia and then posteromedially. Progressive soft tissue release was carried out until symmetrical, medial-lateral balance was confirmed using a trial prosthesis after femoral and tibial articular surface resection. The initial medial release was extended ≥1 cm distally in all of the medial release group (n=20). Medial-lateral tension was assessed with the knee in extension and 90° flexion. If medial soft tissue contracture was noted in extension, the deep layer of the MCL and the postero-medial joint capsule were released; whereas the superficial layer of the MCL and the anteromedial joint capsule were released, if contracture was noted in 90° flexion to obtain a perfect ligament balance.

In the vertical osteotomy group, a midvastus approach was used for joint exposure. Soft tissue release was started in the subperiosteal layer of the joint capsular insertion site on the proximal tibia and extended 1 cm distally and posteromedially. Subsequently, without further release, femoral and tibial articular surface resection was carried out and ligament balance was assessed using a trial prosthesis. Taking care to achieve symmetrical medial-lateral tension with the use of a prosthesis that is one size smaller than the trial one, an osteotome was inserted perpendicular to the resected articular surface for bone tissue removal in the proximal medial tibia. The bone resection was performed in 2 mm increments according to the level of the medial soft tissue contracture until a perfect ligament balance was confirmed with the insertion of the trial prosthesis.

Comparisons between the groups were based on the total operation (OP) time, ROM, HSS score, tibio-femoral medial-lateral gap ratio examined with the knee in 0°, 90°, and 130° flexion under an image intensifier at 6 months postoperatively.

Total OP time starting from the initial skin incision to skin closure was measured. On the assessment of ROM at postoperative 6 months, the difference in the angle created by the femoral longitudinal axis and the tibial longitudinal axis with the knee in maximum flexion and extension on lateral radiographs was recorded.

To assess the tibio-femoral medial-lateral gap ratio at postoperative 6 months, the patient was placed in the supine position with the knee in 0°, 90°, and 130° flexion under an image magnifier that was set up to produce a cross-sectional image of the tibial articular surface on the AP view. The medial and lateral tibio-femoral gaps were measured with the knee in 0°, 90°, and 130° flexion on the picture archiving and communication system (PACS) and the lateral value was divided by the medial value to obtain the ratio at each flexion angle (Fig. 3).

Statistical analysis was performed using SPSS ver. 15.0 (SPSS Inc., Chicago, IL, USA) in order to analyze total OP time, ROM, HSS score, and tibio-femoral medial-lateral gap ratio at postoperative 6 months. The Mann-Whitney test was conducted to compare differences between the groups with a 95% confidence interval.

Fig. 1. Anteroposterior radiograph of both knees showing arthritic change of the medial, tibio-femoral joint with severe varus deformity.
Table 1. Clinical Raw Data for Total Knee Arthroplasty Cases with Mechanical Varus Deformity More Than 10°

| No. | Age (yr) | Osteotomy/ release | Varus (°) | Operation time (min) | Postoperative ROM | HSS | Medial-lateral ratio | Preoperative ROM | HSS |
|-----|----------|---------------------|----------|----------------------|------------------|-----|---------------------|------------------|-----|
| 1   | 69       | Osteotomy           | 13       | 100                  | 135              | 93  | 1.1                 | 135              | 65  |
| 2   | 71       | Osteotomy           | 12       | 98                   | 130              | 94  | 1.1                 | 120              | 60  |
| 3   | 72       | Osteotomy           | 15       | 99                   | 140              | 90  | 1.1                 | 135              | 62  |
| 4   | 67       | Osteotomy           | 13       | 85                   | 130              | 91  | 1                  | 130              | 60  |
| 5   | 70       | Osteotomy           | 11       | 119                  | 135              | 96  | 1.1                 | 130              | 55  |
| 6   | 69       | Osteotomy           | 14       | 101                  | 133              | 98  | 1                  | 130              | 65  |
| 7   | 68       | Osteotomy           | 15       | 89                   | 132              | 96  | 1.1                 | 130              | 57  |
| 8   | 66       | Osteotomy           | 12       | 90                   | 136              | 94  | 1                  | 125              | 63  |
| 9   | 72       | Osteotomy           | 14       | 105                  | 132              | 92  | 1                  | 135              | 68  |
| 10  | 73       | Osteotomy           | 11       | 80                   | 128              | 90  | 1                  | 125              | 65  |
| 11  | 74       | Osteotomy           | 11       | 95                   | 136              | 92  | 1.1                 | 130              | 72  |
| 12  | 71       | Osteotomy           | 13       | 100                  | 137              | 88  | 1                  | 95               | 63  |
| 13  | 69       | Osteotomy           | 15       | 97                   | 142              | 90  | 1                  | 135              | 68  |
| 14  | 70       | Osteotomy           | 12       | 95                   | 136              | 94  | 1                  | 130              | 70  |
| 15  | 81       | Osteotomy           | 11       | 105                  | 135              | 96  | 1                  | 125              | 62  |
| 16  | 82       | Osteotomy           | 13       | 89                   | 132              | 96  | 1                  | 130              | 57  |
| 17  | 77       | Osteotomy           | 19       | 85                   | 133              | 92  | 1                  | 135              | 66  |
| 18  | 65       | Osteotomy           | 11       | 105                  | 131              | 94  | 1                  | 125              | 57  |
| 19  | 64       | Osteotomy           | 13       | 110                  | 138              | 92  | 1                  | 130              | 61  |
| 20  | 62       | Osteotomy           | 17       | 90                   | 138              | 90  | 1                  | 85               | 64  |
| 21  | 83       | Release             | 13       | 115                  | 140              | 92  | 1.2                | 135              | 56  |
| 22  | 73       | Release             | 12       | 111                  | 133              | 94  | 1.1                 | 130              | 65  |
| 23  | 77       | Release             | 11       | 109                  | 132              | 96  | 1.1                 | 125              | 67  |
| 24  | 69       | Release             | 13       | 113                  | 135              | 90  | 1                  | 120              | 71  |
| 25  | 71       | Release             | 11       | 125                  | 133              | 92  | 1.2                | 125              | 65  |
| 26  | 72       | Release             | 18       | 119                  | 136              | 94  | 1.2                 | 125              | 66  |
| 27  | 73       | Release             | 11       | 112                  | 130              | 90  | 1.2                | 120              | 69  |
| 28  | 74       | Release             | 17       | 118                  | 142              | 96  | 1                  | 135              | 63  |
| 29  | 77       | Release             | 16       | 125                  | 140              | 94  | 1.2                | 90               | 59  |
| 30  | 64       | Release             | 11       | 118                  | 133              | 92  | 1                  | 125              | 64  |
| 31  | 65       | Release             | 15       | 110                  | 135              | 92  | 1                  | 130              | 70  |
| 32  | 66       | Release             | 12       | 118                  | 136              | 90  | 1.1                 | 130              | 71  |
| 33  | 73       | Release             | 11       | 110                  | 137              | 94  | 1                  | 125              | 63  |
| 34  | 70       | Release             | 15       | 109                  | 138              | 92  | 1.2                | 135              | 68  |
| 35  | 81       | Release             | 14       | 110                  | 136              | 90  | 1.1                | 130              | 65  |
| 36  | 82       | Release             | 15       | 121                  | 137              | 92  | 1.2                | 135              | 57  |
| 37  | 69       | Release             | 14       | 118                  | 138              | 94  | 1.1                 | 90               | 61  |
| 38  | 63       | Release             | 11       | 123                  | 132              | 96  | 1                  | 125              | 64  |
| 39  | 71       | Release             | 12       | 121                  | 130              | 92  | 1                  | 120              | 63  |
| 40  | 77       | Release             | 13       | 119                  | 135              | 90  | 1.2                | 125              | 66  |

ROM: range of motion, HSS: hospital for special surgery.
Results

Statistically significant intergroup differences were found in the total OP time and the tibio-femoral medial-lateral gap ratio in 130° flexion. There was no significant difference in the preoperative HSS score and tibio-femoral angle on the whole leg standing AP view and postoperative ROM, HSS score, and tibio-femoral medial-lateral gap ratio in 0° and 90° flexion. The mean total OP time was remarkably short in the vertical osteotomy group (mean, 96.9 minutes; range, 80 to 119 minutes) compared to that in the medial release group (mean, 116.2 minutes; range, 109 to 125 minutes) (p=0.000). The mean tibio-femoral medial-lateral gap ratio in 130° flexion at postoperative 6 months was notably smaller in the vertical osteotomy group (1.02) than in the medial release group (1.14; p=0.000). However, the ratio was not significantly different between the groups in 0° and 90° flexion.

Discussion

There is a variety of surgical techniques for the treatment of degenerative arthritis of the knee according to the severity and extent of a lesion. Of these, TKA is the most common surgical intervention for profound degenerative arthritis in senior patients. Ligament balance is essential to the success of TKA and imbalance has been recognized as one of the major causes of early failure of TKA as well as pain during ambulation. Sequential medial soft tissue release has been widely performed in varus arthritic knees, however, profound varus deformity often necessitates additional soft tissue release in the MCL and joint capsule. An extensive medial soft tissue release performed in severe varus knees may result in overcorrection, for which a thick polyethylene insert or a constrained prosthesis should be used when a patient undergoes TKA. The conventional ligament balancing procedure involves removal of degenerative osteophytes and release of the contracted medial soft tissue at the tibial attachment site to obtain symmetrical medial-lateral tension in extension and 90° flexion of the knee. This technique is advantageous in that various medial soft tissues, including the superficial and deep layers of the MCL, can be selectively released.
to adjust medial tension in extension and 90° flexion of the knee. However, it is difficult to avoid medial soft tissue rupture during the procedure. To overcome this disadvantage, Dixon et al. suggested longitudinal resection of the proximal medial tibia. Their method minimizes soft tissue release to prevent medial soft tissue rupture and uses vertical resection of the proximal medial tibia for ligament balance. Hence, it is expected to be more effective and safer than the conventional procedure, allowing minimal release of the superficial layer of the MCL in the tibial attachment site.

In this study, we compared the 2 ligament balancing techniques based on the total OP time, preoperative and 6-month postoperative ROM and HSS score, and tibiofemoral medial-lateral gap ratio in 0°, 90°, and 130° flexion. There were statistically significant differences in the total OP time and the ratio in 130° knee flexion. The mean total OP time was longer in the medial release group than in the vertical osteotomy group. We attributed this to the use of a sequential release procedure to prevent excessive soft tissue release according to recommendations and technical difficulties caused by adhesion and contracture of medial soft tissues in knees with degenerative arthritis. The mean total OP time in the medial release group could have been lengthened due to staple fixation in 2 cases with a partial rupture of the superficial layer of the MCL. The 2 cases were not excluded from the analysis under the assumption that the ruptures represented the risk of medial soft tissue release. The significantly lower tibio-femoral medial-lateral gap ratio in 130° knee flexion could be attributable to the lack of an aggressive medial release to avoid the possibility of medial soft tissue instability. The difference in the ratio in 130° knee flexion did not result in significant intergroup difference in ROM. In spite of this, the results are worth consideration in TKA for Asian patients, because hyperflexion of the knee is often necessary in Asian culture.

Proximal medial tibial resection can be an effective method for ligament balancing. However, an extensive bone resection may cause tibial component loosening, difficulty in revision surgery,

Table 2. Comparison between Vertical Osteotomy Group and Medial Release Group

| Group            | Mean±SD (range) | p-value |
|------------------|-----------------|---------|
| Age (yr)         | 0.222           |         |
| Osteotomy        | 70.6±5.12 (62–82) |         |
| Release          | 72.5±5.77 (63–83) |         |
| Varus (°)        | 0.978           |         |
| Osteotomy        | 13.25±2.15 (11–19) |         |
| Release          | 13.25±2.17 (11–18) |         |
| Operation time (min) | 0.000       |         |
| Osteotomy        | 96.85±9.44 (80–119) |         |
| Release          | 116.20±5.39 (109–125) |         |
| Postoperative ROM | 0.376         |         |
| Osteotomy        | 134.45±3.58 (128–142) |         |
| Release          | 135.40±3.28 (130–142) |         |
| Postoperative HSS | 0.718         |         |
| Osteotomy        | 92.90±2.65 (88–98) |         |
| Release          | 92.60±2.06 (90–96) |         |
| Medial-lateral ratio (0°) | 0.553        |         |
| Osteotomy        | 1.01±0.03 (1.0–1.1) |         |
| Release          | 1.01±0.02 (1.0–1.1) |         |
| Medial-lateral ratio (90°) | 0.938       |         |
| Osteotomy        | 1.02±0.04 (1.0–1.1) |         |
| Release          | 1.03±0.06 (1.0–1.2) |         |
| Medial-lateral ratio (130°) | 0.000       |         |
| Osteotomy        | 1.02±0.04 (1.0–1.1) |         |
| Release          | 1.14±0.07 (1.0–1.2) |         |
| Preoperative ROM  | 0.567           |         |
| Osteotomy        | 123.75±15.21 (85–135) |         |
| Release          | 124.25±12.59 (90–135) |         |
| Preoperative HSS  | 0.212           |         |
| Osteotomy        | 63.00±4.58 (55–72) |         |
| Release          | 64.65±4.21 (56–71) |         |

SD: standard deviation, ROM: range of motion, HSS: hospital for special surgery.
and kinematic changes in the knee due to lateral translation of the tibial component. Although extensive medial soft tissue release has been associated with knee instability in some studies, Choi et al.\(^2\) suggested that proper postoperative fixation could improve stability in knees with varus deformity even after extensive release of medial soft tissues including the MCL.

One of the limitations of this study is the 6-month short-term follow-up period in comparison to other studies. Although TKAs were bilateral in 13 of the 27 patients, the influence of personal differences on the postoperative ROM and HSS score were not taken into consideration in the analysis. In addition, the mediolateral gap was measured without weight bearing and thus the results may not reflect the possibility of instability during walking or daily living activities. The difference in the tibio-femoral mediolateral gap ratio in 130° flexion might have originated from the difference in the axis of knee flexion. Furthermore, the results could have been affected by the surgeon’s preference or skills considering that all the operations were performed by the same surgeon in this study.

**Conclusions**

The 6-month short-term follow-up results of TKA showed that proximal medial tibial resection in severe varus knees can be effective in reducing operation time and achieving ligament balance in high flexion. We believe possible complications related to the procedure should be investigated in future long-term follow-up studies.

**Conflict of Interest**

No potential conflict of interest relevant to this article was reported.

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