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Research Article

Cartilage Regeneration in Knees with Lateral Unicompartmental Osteoarthritis Following Distal Femoral Varus Osteotomy

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Abstract

Valgus deformity of the knee joint leading to lateral unicompartmental osteoarthritis is challenging for orthopedic surgeons. We aimed to clarify the characteristics of cartilage regeneration over the lateral compartment after arthroscopic subchondral drilling with concomitant distal femoral varus osteotomy (DFVO) and assess limb alignment correction postoperatively. Thirty knees were operated on, and the clinical outcomes and severity of lateral knee pain were evaluated. The major finding was that degenerative articular cartilage was partially or fully regenerated, and functional improvement and lower limb alignment correction were achieved after DFVO. The data suggested that DFVO achieves functional improvement and pain relief. With careful preoperative planning and intraoperative procedures, optimal angle correction can be achieved. In conclusion, DFVO with concomitant subchondral drilling provides reliable mechanical alignment as well as considerable cartilage regeneration over the lateral compartment.

Keywords: Distal Femoral Varus Osteotomy; Cartilage Regeneration; Mechanical Tibiofemoral Angle; Mechanical Lateral Distal Femoral Angle; Weight Bearing Line

Introduction

Valgus deformity of the knee joint leading to lateral unicompartmental osteoarthritis in young and active patients is a challenging presentation for orthopedic surgeons. Valgus malalignment results in mechanical overload of the lateral joint compartment and hastens compartmental degeneration. Left untreated, lateral cartilage and meniscal damage progresses and leads to clinical symptoms such as pain. Despite total knee replacement offering fair symptomatic relief and enduring implant survivorship in aged patients, the high revision rate in young patients remains a cause of concern [1].

In cases of lower limb malalignment, osteotomy around the knee is an alternative to total knee replacement. This joint-preserving procedure offers reliable pain remission, functional improvement, and permits relatively heavy functional loading that is best avoided after joint replacement surgery [2]. Distal femoral varus osteotomy (DFVO) has been used to treat valgus knee deformities with satisfactory results [3-6]. A recent trend has been to combine osteotomies with various cartilage repair techniques to promote cartilage regeneration. A systematic review showed that concomitant cartilage repair procedures during high tibial osteotomy (HTO) might provide multiple favorable effects, including positive arthroscopic, histological, and magnetic resonance findings [7]. Another review, on animal studies, suggested that subchondral drilling offers superior articular cartilage repair than spontaneous repair does. However, studies have not yet evaluated cartilage regeneration or changes in second-look arthroscopy following DFVO [8].

Our study aimed to clarify the characteristics of cartilage regeneration over the lateral compartment after arthroscopic subchondral drilling with concomitant DFVO and to assess the limb alignment correction postoperatively. We hypothesized that this combination would contribute to cartilage regeneration and achieve optimal mechanical alignment of the lower limb.

Materials and Methods

This study was a retrospective sequential review using data collected from the National Taiwan University Hospital between July 2015 and March 2020. A total of 30 knees in 28 patients with lateral compartmental osteoarthritis and cartilage degeneration were subjected to subchondral drilling with concomitant DFVO. The inclusion criteria of this study were as follows: (1) isolated lateral compartment knee pain with valgus tibiofemoral malalignment, (2) neither cruciate nor collateral ligament insufficiency, and (3) a flexion contracture of <15°. The exclusion criteria were as follows: (1) knee flexion angle <90°, (2) patellofemoral degenerative disease, and (3) active knee infection, inflammatory arthritis, or immunosuppressive therapy. The plates and screws had already been removed from six patients in this study who had undergone second-look arthroscopy.

This study was approved by the Ethics Committee of the National Taiwan University Hospital, and a waiver for the requirement of informed consent for the retrospective use of patient data (Approval Number: 202005120RINB) was obtained.

Preoperative planning for DFVO

Standard anteroposterior (AP), lateral, and merchant view radiography was performed for preoperative evaluation. A longitudinal radiograph of the bilateral lower limbs in the coronal plane was taken to evaluate the degree of valgus deformity of the affected knee joints. The mechanical axis was taken as the line connecting the center of the femoral head and center of the talar dome (Figure 1a). The weight-bearing percentage was calculated using the point at which the tibial plateau crosses the mechanical axis, with the medial edge of the tibial plateau designated as 0% and the lateral edge as 100%. The angular correction was determined from the mechanical tibiofemoral angle, that is, angle between the femoral (line connecting the center of the femoral head and center of the tibial plateau) and tibial mechanical axes (line connecting the center of the tibial plateau and center of the talar dome), as shown in figure 1b.

Surgical procedures

All of the patients were diagnosed with lateral unicompartmental knee osteoarthritis and received DFVO from the author (JHW). Routine knee arthroscopy was performed prior to DFVO to evaluate the degree of cartilage degeneration, and the Pridie procedure and a partial meniscectomy were also performed simultaneously. During the Pridie procedure, holes were drilled deep enough to engage the bone marrow, as shown in figure 2. After the arthroscopic procedure, concomitant DFVO was performed with a locking plate fixation. At the time of implant removal, a follow-up knee arthroscopy was performed for second-look articular cartilage examination. The details of the surgical procedure have been published [9,10].

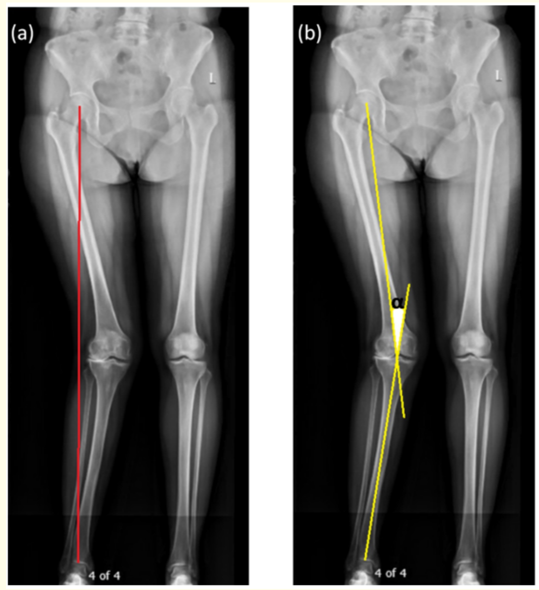

Figure 1: (a) Radiograph of long leg standing view to assess longitudinal axis alignment in the coronal plane as indicated by the red line (b) Determination of the angular correction by mechanical tibiofemoral angle α.

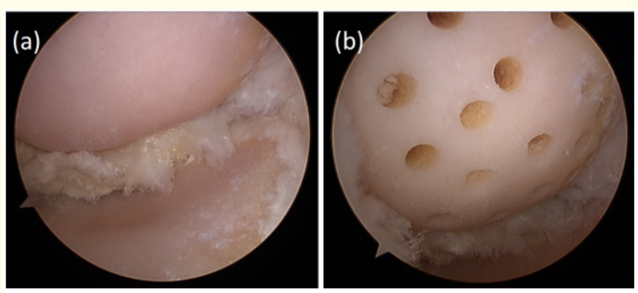

Figure 2: Intra-operative arthroscopic views of the lateral compartment of the right knee (a) before and (b) after subchondral drilling of the lateral femoral condyle.

Postoperative rehabilitation

A rehabilitation program involving isometric quadriceps and knee joint range-of-motion exercises was initiated the day after osteotomy. For the first 1–2 weeks, patients underwent non–weight bearing ambulation without splint protection. Partial weight bearing was initiated and tolerated before the patients progressed to full weight-bearing ambulation at 2 weeks after surgery.

Clinical outcome

We evaluated the clinical outcomes of the knee joints in our study by using both the Oxford Knee Score and EQ-5D. The severity of lateral knee pain was evaluated using a visual analog scale.

Radiography

Preoperative AP and lateral view radiography were performed to assess the cartilage wear of the knee joint compartment and lower limb alignment. Postoperative radiographs were taken on day 1, at approximately 3 months, and before and after implant removal. Because of the retrospective design of the study, not all radiography was performed at the same dates for every patient. Serial radiographs are essential for assessing both bone healing and decisions relating to weight-bearing protocols. All radiographs were equidistant from the X-ray beam and cassette. These images were then transferred to a picture archiving and communication system; therein, 0.1° and 0.1-mm knee measurements were performed and digitally and recorded.

Alignment assessment was based the following five measurements captured preoperatively and postoperatively: (1) mechanical tibiofemoral angle (mTFA), (2) mechanical medial proximal tibial angle (mMPTA), (3) mechanical lateral distal tibial angle (mLDTA), (4) mechanical lateral proximal femoral angle (mLPFA), and (5) mechanical lateral distal femoral angle (mLDFA). For mTFA, negative values represent varus alignment, and positive values represent valgus alignment.

Arthroscopy

Articular cartilage status was evaluated through arthroscopy both prior to DFVO surgery and during implant removal. Six patients in this study received second-look arthroscopy during hardware removal. Cartilage wear was graded in accordance with the International Cartilage Repair Society (ICRS) evaluation system. The degree of cartilage regeneration was also assessed using an alternative grading system proposed by Koshino., *et al*. [11] in which stage A represents no newly formed cartilaginous tissue, stage B represents partial regeneration, and stage C represents total cartilage regeneration. Figure 3 shows a comparison between preoperative and postoperative articular cartilage coverage of one of the cases.

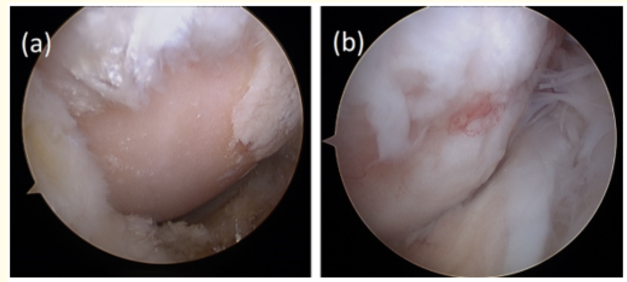

Figure 3: Arthroscopic views of articular cartilage coverage at (a) initial arthroscopy and (b) second-look arthroscopy in a 65-year-old female patient.

Statistics

All statistical analyses were performed using SAS 9.4 on a Windows computer. The preoperative and postoperative clinical findings as well as radiographic results were compared using paired t tests, and a P value < 0.05 was considered statistically significant. The mean value and 95% confidence intervals of functional scores and knee angles were calculated.

Results

Demographic characteristics

Data on 30 DFVO procedures performed in 28 patients were analyzed. The mean age at which the surgery was performed was 57.1 ± 9.2 years, and the ages ranged from 21 to 71 years. Four patients were men, and 24 were women. The average follow-up time was 20.4 ± 12.3 months, with follow-ups ranging from 4 to 57 months. For the six patients whose implants had already been removed, the mean duration from osteotomy to second-look arthroscopy and hardware removal was 14.7 ± 2.3 months. The demographic data are shown in table 1.

Knee number	30
Patient number	28
Gender	4 men / 24 women
Age at DFVO, yr	57.1 ± 9.2 (21 to 71)
Average follow-up time, mo	20.4 ± 12.3 (4 to 57)
Time interval from initial operation to removal operation, mo	14.7 ± 2.3 (10 to 17)

Table 1: Patient demographic characteristics.

Clinical and radiographic results

Preoperative and postoperative measurements were as follows: (1) mean Oxford knee score improved from 19.8 ± 11.2 to 40.0 ± 7.1, (2) mean EQ-5D score improved from 10.8 ± 2.4 to 6.8 ± 1.6, and (3) mean 10-cm visual analog scale for lateral knee pain decreased from 6.8 ± 2.0 cm to 1.4 ± 1.2 cm (Table 2). All three improvements were statistically significant ($P < 0.05$).

Pre-op	Post-op	P-value
19.8 ± 11.2 (0 to 33)	40.0 ± 7.1 (28 to 48)	0.04
10.8 ± 2.4 (8 to 15)	6.8 ± 1.6 (5 to 9)	0.03
6.8 ± 2.0 (4 to 10)	1.4 ± 1.2 (0 to 3)	0.02

Table 2: Clinical outcome.

The mean preoperative mechanical axis angles of mTFA, mLPFA, mLDFA, mMPTA, and mLDTA were 8.8° ± 4.4°, 88.4° ± 5.3°, 84.5° ± 3.3°, 91.6° ± 3.2°, and 89.5° ± 5.4°, respectively. The mean postoperative angles were 1.5° ± 5.3°, 88.0° ± 5.6°, 90.0° ± 5.6°, 90.5° ± 3.4°, and 88.3° ± 6.6°, respectively. The changes in both mTFA and mLDFA were statistically significant ($P < 0.001$), and the mean angle corrections were −7.3° ± 5.8° and 5.5° ± 6.0°, respectively. Change in mMPTA was also statistically significant ($P < 0.05$), with mean angle correction of −1.0° ± 2.1°. On average, the weight-bearing percentage shifted from 82.7% ± 19.8% before to 52.7% ± 24.3% after osteotomy, with high statistical significance ($P < 0.001$). The data are shown in table 3.

Findings	Pre-op	Post-op	P-value
mTFA, degree	8.8 ± 4.4	1.5 ± 5.3	< 0.001
	Mean Correction Angle: -7.3 ± 5.8		
mLPFA, degree	88.4 ± 5.3	88.0 ± 5.6	0.422
mLDFA, degree	84.5 ± 3.3	90.0 ± 5.6	< 0.001
mMPTA, degree	91.6 ± 3.2	90.5 ± 3.4	0.014
mLDTA, degree	89.5 ± 5.4	88.3 ± 6.6	0.071
Weight-bearing percentage, %	82.7 ± 19.8	52.7 ± 24.3	< 0.001

Table 3: Mechanical alignment changes.

Cartilage regeneration

A significant improvement in cartilage status was discovered among the six patients who received second-look arthroscopic evaluation. During the initial arthroscopy using the ICRS criteria, four knees were considered grade 4, one knee was grade 3, and one knee was grade 1. During the follow-up second-look arthroscopy, one knee was considered grade 4, three knees were grade 2, and two knees were grade 1. Three of the patients attained Koshino stage B (partial regeneration), and three attained stage C (total regeneration). The results suggested that 100% of the patients had at least partial regeneration of cartilage tissue and up to 50% of the patients had total cartilage regeneration. The cartilage evaluation data of the six patients are shown in tables 4 and 5.

ICRS grading	Pre-HTO (%)	Second look (%)
1 (superficial)	1(16.7)	2(33.3)
2 (<50% lesion)	0(0)	3(50)
3 (>50% lesion)	1(16.7)	0(0)
4 (subchondral wearing)	4(66.7)	1(16.7)

Table 4: Cartilage regeneration by ICRS grading system.

Koshino grading	Number (%)
A (No regeneration)	0(0)
B (Partial regeneration)	3(50)
C (Total coverage)	3(50)

Table 5: Cartilage regeneration at second-look arthroscopy by Koshino grading system.

Discussion

We evaluated articular cartilage regeneration in knees with lateral unicompartmental osteoarthritis after DFVO with subchondral drilling using second-look arthroscopy and assessed the lower limb alignment correction postoperatively. The major finding is that degenerative articular cartilage was partially or fully regenerated through this combination of DFVO and concomitant subchondral drilling. In addition, functional improvement and lower limb alignment correction were achieved after DFVO. The results indicated that combining DFVO with subchondral drilling contributes to cartilage regeneration and mechanical alignment correction of the lower limb.

DFVO is an effective procedure for pain relief and functional retrieval, especially in young and active patients with lateral knee osteoarthritis [3-6]. Arthroscopic evaluation to address intra-articular pathology prior to osteotomy is commonly performed [12,13]; however, second-look arthroscopy after osteotomy is performed less frequently. Several studies have assessed cartilage regeneration after HTO. Jung., *et al*. [14] conducted a retrospective study comparing fibrocartilage formation 2 years after surgery in patients who did and who did not undergo subchondral drilling during medial opening-wedge high tibial osteotomy (MOWHTO).

In group 1, 30 knees in 30 patients underwent HTO with a concurrent subchondral drilling procedure, whereas in group 2, 31 knees and 31 patients underwent only HTO. The results showed that cartilage regeneration was achieved by 100% of patients in group 1 and only 94% of patients in group 2 (P = 0.492). Although the difference was not statistically significant, the results supported the contribution of HTO to articular cartilage regeneration.

Kim., *et al*. [15] conducted another retrospective study to evaluate cartilage regeneration after MOWHTO and to identify predictive factors for cartilage regeneration. A total of 104 knees in 85 patients underwent MOWHTO, and second-look arthroscopy was performed during implant removal 2 years after osteotomy. The researchers found that 75 knees (72%) had partial or total cartilage regeneration in the medial femoral condyle, and 57 knees (55%) had partial or total cartilage regeneration in the medial tibial plateau. The results indicated that medial compartment cartilage regenerates after treatment with MOWHTO for knee osteoarthritis with varus deformity. Kim., *et al*. [15] also suggested that cartilage regeneration was more likely in patients with lower body mass indices.

Schuster., *et al*. [16] reviewed 91 knees in 85 patients with at least Kellgren–Lawrence grade 3 varus osteoarthritis and full-thickness cartilage defects. MOWHTO was performed on all patients with a concomitant chondral resurfacing procedure (abrasion or microfracture) and second-look arthroscopy between 1 and 2 years after the operation. On the tibial side, 50.0% had good cartilage regeneration, and 25.8% had excellent regeneration. On the femoral side, 48.1% had good grading, and 39.0% had excellent grading. Schuster., *et al*. concluded that to treat severe medial osteoarthritis with varus deformity, HTO with concomitant chondral resurfacing procedure could be an effective treatment.

Cartilage regeneration after DFVO has not been thoroughly studies. Song., *et al*. [17] presented two cases of valgus knee osteoarthritis treated with distal femoral osteotomy and human umbilical cord blood–derived mesenchymal stem cell implantation. During second-look arthroscopy, both patients achieved ICRS grade 1 scores for cartilage regeneration, which indicates similarity to a normal condition. In the present study, cartilage regeneration was observed after DFVO in combination with subchondral drilling. The proportions of patients with ICRS grade 3 or 4 improved from 83.3% before to 16.7% after operation. In addition, improvements in functional outcomes and reduced pain levels were noted.

Limitations

This study has several limitations. First, this was a retrospective, observational series. Second, the sample size was small. Third, the follow-up duration was relatively short, and some delayed outcome changes were masked. Also, numerous patients in our study had not had their implants removed or undergone second-look arthroscopy; thus, a longer follow-up was required. Fourth, the sample predominantly included female patients. Nevertheless, previous studies have revealed that knee osteoarthritis is more common in women [18,19].

Conclusion

Our data suggest that DFVO achieves both functional improvement and pain relief. With careful preoperative planning and intraoperative procedures, optimal angle correction can be achieved. Second-look arthroscopy shows good cartilage regeneration over the lateral compartment at approximately 15 months after operation. In conclusion, DFVO with concomitant subchondral drilling provides reliable mechanical alignment as well as considerable cartilage regeneration over the lateral compartment.

Bibliography

1. Santaguida PL., *et al*. "Patient characteristics affecting the prognosis of total hip and knee joint arthroplasty: a systematic review". *Canadian Journal of Surgery* 51.6 (2008): 428-436.

2. Hanssen AD., *et al*. "Surgical options for the middle-aged patient with osteoarthritis of the knee joint". *Journal of Bone and Joint Surgery* 82-A.12 (2000): 1768-1781.

3. Backstein D., *et al*. "Long-term follow-up of distal femoral varus osteotomy of the knee". *Journal of Arthroplasty* 22 (2007): 2-6.

4. Kosashvili Y., *et al*. "Distal femoral varus osteotomy for lateral osteoarthritis of the knee: a minimum ten-year follow-up". *International Orthopaedics* 34 (2010): 249-254.

5. Cameron JI., *et al*. "Lateral opening-wedge distal femoral osteotomy: pain relief, functional improvement, and survivorship at 5 years". *Clinical Orthopaedics and Related Research* 473 (2015): 2009-2015.

6. Thein R., *et al*. "Distal femoral osteotomy for valgus arthritic knees". *Journal of Orthopaedic Science* 17 (2012): 745-749.

7. Lee OS., *et al*. "Effectiveness of concurrent procedures during high tibial osteotomy for medial compartment osteoarthritis: a systematic review and meta-analysis". *Archives of Orthopaedic and Trauma Surgery* 138.2 (2018): 227-236.

8. Gao L., *et al*. "Subchondral drilling for articular cartilage repair: a systematic review of translational research". *Disease Models and Mechanisms* 11.6 (2018).

9. Olivero M., *et al*. "Femoral osteotomies for the valgus knee". *Annals of Joint* 2 (2017): 31-44.

10. Tírico LE., *et al*. "Medial closing-wedge distal femoral osteotomy: fixation with proximal tibial locking plate". *Arthroscopy Techniques* 4.6 (2015): 687-695.

11. Koshino T., *et al*. "Regeneration of degenerated articular cartilage after high tibial valgus osteotomy for medial compartmental osteoarthritis of the knee". *Knee* 10.3 (2003): 229-236.

12. Puddu G., *et al*. "Which osteotomy for a valgus knee?". *International Orthopaedics* 34.2 (2010): 239-247.

13. Gardiner A and Richmond JC. "Periarticular osteotomies for degenerative joint disease of the knee". *Sports Medicine and Arthroscopy Review* 21.1 (2013): 38-46.

14. Jung WH., *et al*. "Comparison of results of medial opening-wedge high tibial osteotomy with and without subchondral drilling". *Arthroscopy* 31.4 (2015): 673-679.

15. Kim KI., *et al*. "Change of chondral lesions and predictive factors after medial open-wedge high tibial osteotomy with a locked plate system". *American Journal of Sports Medicine* 45.7 (2017): 1615-1621.

16. Schuster P., *et al*. "Open-wedge high tibial osteotomy and combined abrasion/microfracture in severe medial osteoarthritis and varus malalignment: 5-year results and arthroscopic findings after 2 years". *Arthroscopy* 31.7 (2015): 1279-1288.

17. Song JS., *et al*. "Cartilage regeneration in osteoarthritic knees treated with distal femoral osteotomy and intra-lesional implantation of allogenic human umbilical cord blood-derived mesenchymal stem cells: a report of two cases". *Knee* 26.6 (2019): 1445-1450.

18. Fransen M., *et al*. "The epidemiology of osteoarthritis in Asia". *International Journal of Rheumatic Diseases* 14.2 (2011): 113-121.

19. Lin FH., *et al*. "The increase in total knee replacement surgery in Taiwan". *Medicine* 97.31 (2018): e11749.