Chondral Resurfacing and High Tibial Osteotomy in the Varus Knee

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Background: Treatment of patients with degenerative knees and varus malalignment presents a difficult clinical problem.

Hypothesis: Combining a medial opening wedge high tibial osteotomy with the microfracture chondral resurfacing procedure is a viable treatment option.

Study Design: Retrospective review of prospectively collected data.

Methods: A group of 38 consecutive patients (mean age, 51.3 years; range, 34 to 72 years; 29 men and 10 women) with varus malalignment and chondral lesions who were treated with chondral resurfacing (an abrasion and microfracture technique) combined with a medial opening wedge high tibial osteotomy. All patients had >5° of varus malalignment. Patients were evaluated preoperatively with the Lysholm and Western Ontario & McMasters Universities Osteoarthritis Index scoring systems and at a minimum of 2 years follow-up.

Results: Thirty-three of 38 patients (87%) were available for 2-year follow-up (average, 45 months; range, 24 to 80 months). Lysholm scores improved from a preoperative score of 43.5 to 78.0 at follow-up; Western Ontario & McMasters Universities Osteoarthritis Index scores improved from 45.8 to 16.2. The average Tegner score was 5.0.

Conclusions: Combining a medial opening wedge high tibial osteotomy with the microfracture chondral resurfacing procedure in the varus knee is an effective method of decreasing pain and increasing function at a minimum of 2 years follow-up.

Keywords: high tibial osteotomy; chondral resurfacing; microfracture; degenerative knee; varus malalignment

Beginning in 1981, chondral resurfacing procedures of articular cartilage defects have been performed extensively. Techniques currently used for chondral resurfacing of articular cartilage defects include abrasion with or without microfracture,[4,20,25,26] dowel-type plugs such as mosaicplasty or OATS,[12,15] and dowel plugs with allograft or autologous cell transfer.[23] These techniques are all used commonly and seem to be beneficial in the acutely damaged nonarthritic knee.

In the past, an unloading osteotomy helped to decrease the pressure on the articular surface of degenerative knees with varus malalignment.[1,5,6,7,8,14,16,22] Procedures such as shortening an already shortened leg, problems with the proximal tibiofibular joint, operating in and around the peroneal nerve,[24] and the closing wedge osteotomy concerned us. We began performing an opening wedge osteotomy on the medial side of the proximal tibia in conjunction with a chondral resurfacing procedure in the degenerative varus knee in 1995. This combination produced more accurate realignment, extensile incisions that should not complicate total knee arthroplasty if necessary in the future, and restoration of the native height to the tibia.

The purpose of this study was to determine the outcome of patients with varus malalignment who underwent a chondral resurfacing procedure and a high tibial osteotomy.

MATERIALS AND METHODS

Patient Population

Between 1995 and 1997, 38 patients (28 men and 10 women; average age, 51.3 years; range, 34 to 79 years) underwent an open wedge high tibial osteotomy with a chondral resurfacing procedure by an abrasion technique and microfracture. Patients were candidates for the above procedure when (1) medial chondral degeneration was present; (2) varus malalignment was present, in which the patients' weightbearing axis measured >5° of varus or their weightbearing line fell in the medial third of the tibial plateau, or the weightbearing axis was not fully in the medial third of the tibia but the entire meniscus had been previously excised; (3) the chief complaint was medial sided knee pain; and (4) the desired Tegner activity score was 4 or greater. A grade 4 Tegner score corresponds to moderate work or recreational sports. If the chief com-

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TABLE 1
Patient Treatment History and Associated Pathologies

	Number of Patients
Previous surgeries	
None	11
One	11
Two or greater	16
Pathologies at osteotomy	
ACL (no reconstructions)	4
Medial meniscal	23
Lateral meniscal	8
Chondral pathology	
Medial compartment	37
Lateral compartment	6
Patella/trochlear groove	5

plaint was medial side knee pain, the presence of patellofemoral arthrosis was not a factor in the algorithm for patient selection.

Treatment history of the study patients is summarized in Table 1. Before the surgical procedure, all patients completed subjective self-administered evaluation forms to provide Lysholm[17] and Western Ontario & McMasters Universities Osteoarthritis Index (WOMAC)[3] scores. Patients completed the same forms and reported their Tegner activity level at follow-up.

Figure 1. Weightbearing axis connecting center of the hip to the center of the ankle.

Alignment Measurements

The weightbearing axis of the knee is defined by the angle subtended by a line from the center of the hip to the center of the knee and continued to the center of the ankle. Hsu[13] found that this angle was 1.2° of varus in 120 normal knees. Our way of drawing the lines is slightly different. We draw a line from the center of the hip to the center of the ankle[10] and mark where the line falls at the level of the tibial plateau (Figure 1). In performing an osteotomy, rather than correcting to a particular angle on the anatomic axis, we attempt to move this line to the base of the lateral tibial spine. This line correction shifts the weight to the lateral compartment of the knee. Roughly, it is a 4° correction from normal (typically, measuring 3° of valgus on the weightbearing axis).

Surgical Technique

The patient was placed supine on the operating room table. The head of the bed was reversed to the foot to allow for fluoroscopic visualization from the hip to the ankle. Diagnostic arthroscopy was performed including assessments of the patellofemoral joint and the medial and the lateral compartments. The lateral compartment was evaluated. If extensive grade 4 changes were seen in the lateral compartment, we did not perform the osteotomy. If Grade 4 changes were present but small, less than 2 cm, we still performed an osteotomy but did not overcorrect beyond neutral as we would for a knee without chondral changes in the lateral compartment. The extent of Grade 4 changes in the medial compartment was evaluated. Any concomitant pathology, such as meniscal tear, was treated. Surgical findings at the time of osteotomy are detailed in Table 1.

The chondral resurfacing was begun with trimming any loose flaps of unstable articular cartilage back to a stable rim. This area defined the extent of the lesion (Figure 2). A rough shave was performed in an attempt to generate punctate bleeding from the subchondral bone. A 45° arthroscopic (microfracture) awl (Linvatec, Largo, Fla) was used to make several 2-mm holes in the subchondral bone. These holes were placed as close together as possible without breaking into each other. When the fluid pressure was decreased and good bleeding was seen from each of the microfracture holes, the arthroscope was removed from the knee and the portals were closed.

The leg was prepared again with Betadine, and another sterile extremity drape was applied. Following esmarch exsanguination, the tourniquet was inflated to 250 mm Hg. The external fixator pins (Dynafix, EBI, Warsaw, Ind) were placed approximately 1 cm below the level of the articular surface, parallel to the joint. Using the fixator as a guide, we placed distal pins in a bicortical fashion through the midtibia (Figure 3). Then, we removed the fixator so that the osteotomy could be performed.

Beginning 2 cm below the pin sites, a small 2-cm incision was made in a longitudinal fashion beginning approx-

Figure 2. Grade 4 chondral degeneration of the medial femoral condyle and tibial plateau.

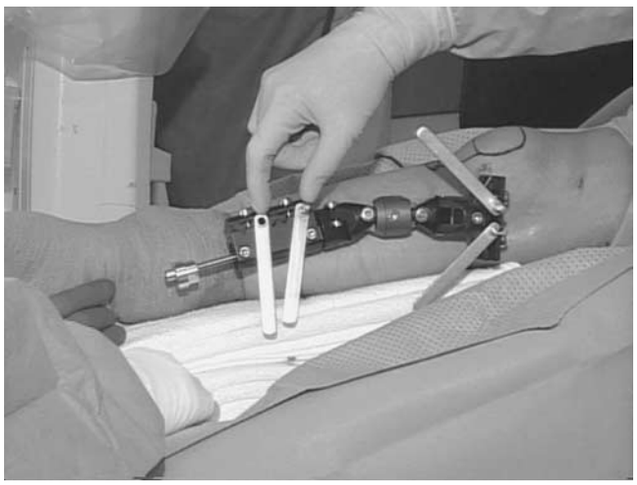

Figure 3. The fixator was used as a guide to place distal pins.

imately 3 cm medial to the tibial tubercle. To preserve the periosteal blood supply, no attempt was made to strip the soft tissues off of the anterior or posterior cortex of the tibia. Using a 4.8-mm drill bit, we made a large borehole in the medial tibia. A 3.2-mm drill bit was used from within the medullary canal where multiple holes were made anterior and posterior from the starting hole (Figure 4). An effort was made not to perforate the lateral cortex. A one-quarter-inch stiletto osteotome was used to "connect the dots" of the multiple 3.2-mm drill holes. A closed osteoclasis was performed to open the osteotomy site. The lateral cortex was preserved.

The fixator was applied, and the desired amount of correction was obtained intraoperatively (Figure 5). The amount of fixator opening required to achieve 1 mm of opening per day at the osteotomy site was calculated. The fixator was closed down at the end of the procedure (Figure 6). All patients used continuous passive motion for 6 hours per day for between 4 and 8 weeks depending on size and extent of the microfracture performed.

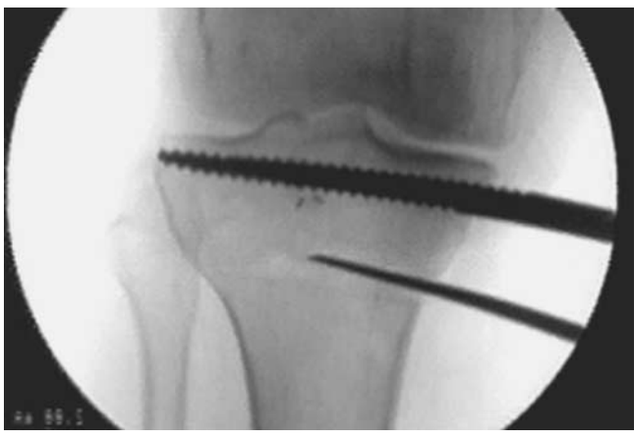

Figure 4. A large borehole was drilled in the medial tibia, and a 3.2-mm drill bit was used to create multiple holes.

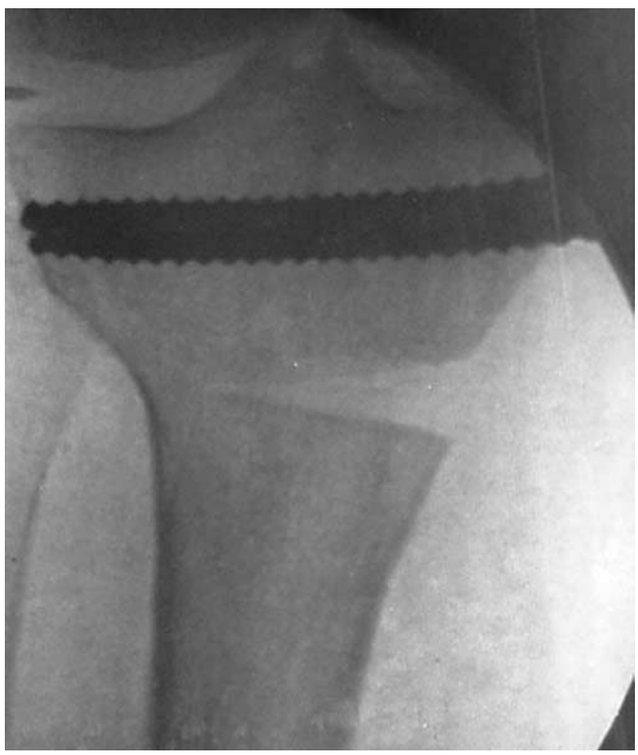

Figure 5. Intraoperative radiograph demonstrating opening of the osteotomy before closure.

Beginning postoperative day 5, the fixator began in divided increments to achieve a 1-mm opening per day at the osteotomy site. Radiographs were obtained 1 week into opening (Figure 7). Opening was continued until the desired amount of correction was achieved (Figure 8). Radiographs were obtained 6 weeks following the completion of distraction. The amount of consolidation was noted (Figure 9), and a decision was made on removal of the fixator. The fixator was removed in the operating room, and a second-look arthroscopy was performed. The amount of regenerate cartilage was documented (Figure 10). In this

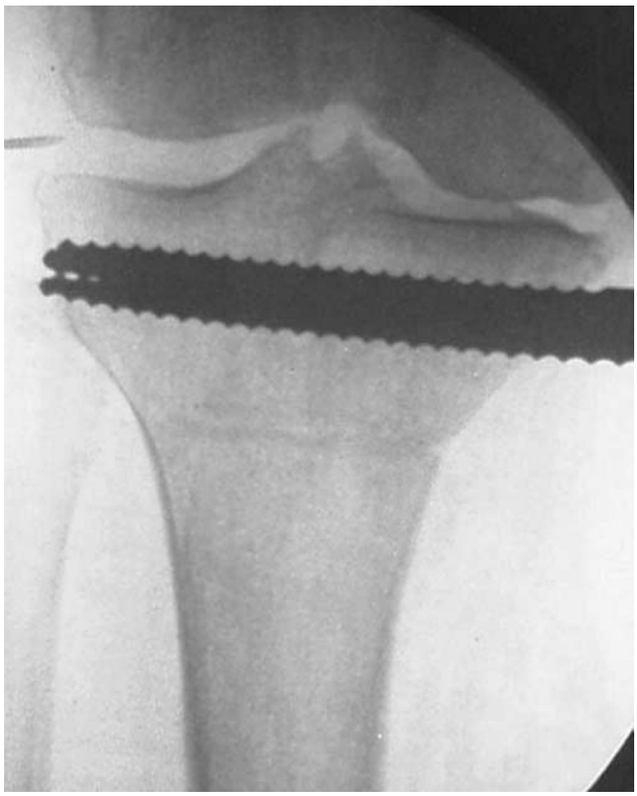

Figure 6. Intraoperative radiograph following osteotomy and placement of external fixator.

Figure 7. One week of distraction (1 mm per day) at osteotomy site.

Figure 8. Distraction completed.

Figure 9. Partial consolidation, 6 weeks postoperatively.

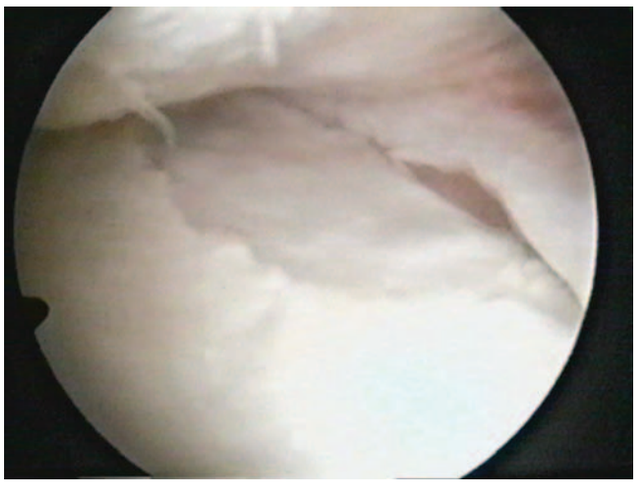

Figure 10. Second-look arthroscopy at 12 weeks following microfracture chondral resurfacing procedure.

Figure 11. Two years postoperatively.

patient group, four patients required re-mircofracture of the chondral surfaces. When patients returned for follow-up, radiographs were obtained to monitor the consolidation (Figure 11).

It is often difficult with regenerate bone to decide when there is "enough" consolidation for safe removal of the external fixator. A variety of methods were used during the course of this study to determine consolidation. These included AP x-rays, CT scans, and occasionally "stress" AP x-rays in varus and valgus. In this patient population, removal of the fixator ranged from 6 weeks to 15 weeks, based on the results of the above studies. Following the removal of the fixator, we allowed the patient to weight bear as tolerated as long as stable consolidation was achieved. Rarely, patients were kept nonweightbearing for up to 3 weeks after removal of the fixator when consolidation was questionable.

TABLE 2
Scores for Study Patients (n = 33)

	Lysholm	WOMAC[a]	Tegner
Preoperative	43.5	45.8	. . .
Range	5-91	0-96	
Postoperative	78.0	16.2	5.0
Range	16-100	0-59	1 to 10
Change	37.5	29.6	. . .
P value	0.001	0.0007	

[a]WOMAC, Western Ontario & McMasters Universities Osteoarthritis Index.

Statistical Analysis

Improvement in Lysholm score was determined using paired *t* tests. Comparison of Lysholm improvement for binary categorical variables was performed using the independent samples *t*-test and for multiple (>2) categorical variables was performed using one-way analysis of variance. Comparison of Lysholm improvement for continuous variables was performed using the Pearson correlation coefficient. Statistical analysis was performed using SPSS (version 11, SPSS Inc, Chicago, Ill) software package. All reported *P* values are two-tailed with an alpha level of 0.05 indicating statistical significance.

RESULTS

Two patients were lost to follow-up. Two patients' knees were considered failures: one patient had a total knee replacement 35 months following high tibial osteotomy (HTO), and another patient had a repeat osteotomy 60 months following initial HTO.

Of the remaining 38 patients, 33 (87%) were available for follow-up at an average of 45 months (range, 24-80 months). The patients' Lysholm, WOMAC, and Tegner activity scores appear in Table 2. One patient's Lysholm score decreased from preoperative to postoperative. Four patients had a slight improvement (increase by 1 to 15 points) in their Lysholm score. Twenty-eight patients showed an improvement in their Lysholm score of greater than 20 points (range, 22-85). There was no correlation between age at time of surgery and improvement in Lysholm. There was also no association between Lysholm improvement and lateral compartment pathology. Those patients with no previous surgeries had higher postoperative Lysholm and more improvement in Lysholm, although it was not significantly higher than patients with a history of previous knee surgery.

TABLE 3
Survival Data[a]

Time (months)	Status	Cumulative Survival	Standard Error	Cumulative Events	Number Remaining
24	Censored[b] (2)			0	32
25-30	Censored (7)			0	25
31-35	Censored (3)			0	22
35	Failed	0.9565	.0425	1	21
36-41	Censored (2)			1	19
42-47	Censored (6)			1	13
48-53	Censored (2)			1	11
54-59	Censored (3)			1	8
60	Failed	.8370	.1179	2	7
61-66	Censored (5)			2	2
67-72	Censored (1)			2	2
80	Censored (1)			2	1

[a] Number of cases: 34; censored: 32 (94.12%); events: 2. Mean survival time = 75.5 months; standard error = 2.9; 95% confidence interval (69.9, 81.1) (limited to 80).
[b] Censored cases are cases for which follow-up is not available past the given time period, therefore are not included in the survivorship analysis past that time period.

Of the 38 patients who underwent the procedure, 15 had infections associated with the external fixator, which required medication. Three patients required intravenous antibiotic treatment, and 12 patients were treated with oral antibiotics. One patient, following premature removal of the fixator, lost correction. There was no association between decreased Lysholm score at follow-up and complications. Correction of 0° to 4° valgus was obtained in 28 patients, 5 patients had 5° to 10o of valgus, and 5 patients had 1° to 6° of varus. In the 2 patients who failed, the correction was 7° and 10° of valgus.

Kaplan-Meir survivorship analysis showed a 96% survivorship at 3 years and an 84% survivorship at 5 years (Table 3). The endpoint for survivorship analysis was defined as a revision HTO or total knee replacement following initial HTO.

DISCUSSION

When performing a chondral resurfacing procedure in conjunction with a high tibial osteotomy in the varus knee, we have found improvement to be predictable and meaningful as evidenced by the Lysholm, WOMAC, and Tegner scores at a minimum of 2-year follow-up (Table 2).

A proximal tibial osteotomy, medial opening or lateral closing, will unload the medial joint,[19] decrease the medial tibial sclerosis,1 and improve the adduction moment about the knee during gait.[11,28] Resurfacing the degenerative knee by using a chondral resurfacing procedure, such as microfracture,[4,25,26] will improve results obtained with an osteotomy alone.[2]

Medial opening wedge osteotomy has several advantages over a lateral closing wedge osteotomy; specifically, it is more controllable than the one-shot accuracy of a closing wedge osteotomy. Using a distraction technique allows fine-tuning of the alignment postoperatively during follow-up clinic visits. The incision should not complicate knee replacement in the future, if such is necessary, because the incision is small and almost directly midline and extensile.

A lateral closing wedge osteotomy shortens a leg. The varus knee is typically already short due to medial collapse. An opening wedge osteotomy will restore the height of this deficient knee. By not having to operate on the lateral side of the proximal tibia, one minimizes complications to either the proximal tibiofibular joint or the peroneal nerve.

Regardless of the amount of correction required in a medial opening wedge osteotomy, we have not found it necessary to either release the proximal tibiofibular joint or perform a fibular osteotomy. In fact, the stability created by leaving the tibiofibular joint intact has been beneficial in our hands.

There are other reports[18] of opening wedge tibial osteotomy by callous distraction. At 1-year follow-up, Magyar et al[18] found an increase in Lysholm scores of 35 points with mean Lysholm scores of 91. We saw similar changes in Lysholm scores in our patients; however, our study population started at lower Lysholm scores.

In 1996, Nagel et al[21] looked at patients (average age, 49 years) who were undergoing a lateral closing wedge osteotomy of the proximal tibial. Their Tegner activity score at follow-up was 4.8. This was not a significant change from the preoperative score. Thus, the patients were able to maintain their level of activity; 82% were willing to have the procedure again.

In patients younger than 55 years of age and undergoing total knee arthroplasty, authors found the Hospital of Special Surgery score increased 37 points at follow-up, roughly equal to the 37.5 increase on the Lysholm score in our study.[27] The Tegner activity score in their patients at follow-up was a mean of 3.5, which was an increase from 1.3 preoperatively. This demonstrated that total knee

arthroplasty could markedly increase the patient's Tegner activity level from a sedentary level to an active productive level of work and sport. Total knee arthroplasty in patients younger than 55 years old had a much lower Tegner activity level both preoperatively and at follow-up than patients undergoing high tibial osteotomy in studies by Diduch et al[9] and Stern et al[27]

One limitation of the current study is the need for longer follow-up. We need to determine if a combined medial open wedge osteotomy and microfracture chondral resurfacing procedure will provide greater longevity in its ability to delay or eliminate the need for arthroplasty as compared to the longevity of patients treated with a closing wedge osteotomy in isolation. An additional limitation is the lack of a control group with medial open wedge osteotomy without microfracture. Although most patients improved, we cannot conclude how much of the improvement was due to the combined procedure versus just an osteotomy.

The results of patients with varus malalignment and lesions requiring chondral resurfacing are extremely promising when they are treated with the combined procedure—microfracture for the chondral resurfacing and high tibial osteotomy. We face a difficult problem with these patients.

In conclusion, our evidence indicates that, at follow-up a minimum of 2 years after the surgical procedure, patients with varus malalignment and chondral surface lesions of the knee can be treated effectively with chondral resurfacing by microfracture and high tibial osteotomy.

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