Original Article

Biointegrative Nail Raftering Improves Pain and Function in Patients With Subchondral Insufficiency of the Knee

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Purpose: To evaluate the utility of implanting biointegrative cannulated nails in a rafter arrangement within the tibial plateau or femoral condyle for treatment of subchondral insufficiency of the knee. **Methods:** Patients were followed for 12 months after surgical intervention for subchondral insufficiency using biointegrative, fiber-reinforced fixation nails. Patients (ages 18-75 years) had moderate knee pain for at least 6 months, unicompartmental Kellgren-Lawrence grade 2-3 and bone marrow lesions confirmed on magnetic resonance imaging (MRI). Comparison of baseline and postoperative Knee Injury and Osteoarthritis Outcome Score (KOOS) was the primary outcome measure. Other patient-reported outcome measures included International Knee Documentation Committee (IKDC) and Patient-reported Outcomes Measurement Information System (PROMIS). Minimal clinically important difference was calculated for each PRO. Calculated bone marrow lesion volumes measured on MRI were compared from baseline to 12 months postoperative. **Results:** Nine patients were included, with follow-up of 12 ± 1 months. Significant improvements were seen in KOOS, IKDC, PROMIS, and Veterans RAND 12-Item Health Survey (VR-12). The average change in patient-reported outcome measures at 12 months were KOOS (19.68, $P = .008$), IKDC (28.99, $P = .004$), PROMIS Pain Interference (10.35, $P = .008$), PROMIS Physical Function (11.06, $P = .008$), and VR-12 Physical (16.14, $P = .008$). Minimal clinically important difference was achieved in 89% of patients for KOOS, 100% for IKDC, 87.5% for PROMIS Pain Interference and Physical Function, and 62.5% for VR-12 Physical. The average decrease in subchondral lesion size measured on MRI did not reach statistical significance ($P = .064$). All patients reported successful return to sport, with no reoperations or implant failures. **Conclusions:** Biointegrative fixation nail raftering for treatment of subchondral insufficiency of the knee resulted in improved patient-reported pain and functionality at 12-month follow-up in the setting of early-to-moderate osteoarthritis. **Level of Evidence:** Level IV, therapeutic case series.

Osteoarthritis (OA) of the knee affects an increasing number of individuals globally each year.[1,2] Anatomical and biomechanical imbalances in the knee are critical factors in OA pathogenesis. Cartilage plays a vital role in shock absorption and low-friction joint movement. Damage to the cartilage significantly reduces the quality of life and accelerates cartilage loss, contributing to OA.[3-5] Meniscal deficiency further exacerbates this issue by impairing load distribution, further increasing the risk of OA.[6,7] The resulting biomechanical disruption overloads the remaining articular cartilage, creating an environment unsuitable for cartilage self-maintenance. This mechanical overload of the tibiofemoral joint can lead to bone marrow edema, which is strongly associated with knee pain in patients with OA.[8-10] Such bone marrow edema lesions are also referred to as subchondral insufficiency of the knee and have shown a correlation with OA progression.[11] Currently, there is limited research on treatment options for these patients that can support the subchondral bone and provide load sharing in the presence of meniscal or chondral deficiency.

In orthopaedic trauma, tibial plateau fractures with intra-articular depression often are treated with small-diameter screws arranged parallel to the articular surface, akin to logs supporting a raft. In addition to fixating the fracture, these "rafter screws" have been shown to provide structural support to the subchondral

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Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Ages 18-75 yr	Subchondral bone collapse
BMI <40	BMLs at ACL or PCL insertions
Knee pain for at least 6 mo	Arthropathies (rheumatoid arthritis, septic arthritis, etc.)
Moderate pain on KOOS Pain Scale	Tobacco use or substance abuse history
Unicompartmental Kellgren-Lawrence grade 2-3 OA	High surgical risk due to preexisting conditions
Bone marrow lesions (BML) confirmed on MRI	Current pregnancy or plans to become pregnant
	Active or chronic knee infections
	Need for concomitant procedures within the study knee (excluding articular cartilage debridement, meniscectomy, microfracture, and loose body removal)
	Contraindications to MRI

ACL, anterior cruciate ligament; BMI, body mass index; BML, bone marrow lesions; KOOS, Knee Injury and Osteoarthritis Outcome; MRI, magnetic resonance imaging; OA, osteoarthritis; PCL, posterior cruciate ligament.

bone and overlying cartilage during fracture healing, reducing pain and potentially abating further progression of OA.[12-15] Although effective in treating tibial plateau fractures, less is known about the use of this technique for the treatment of subchondral insufficiency.

Biointegrative implants have gained attention for their ability to manage orthopaedic pathologies without the need for additional surgeries to remove hardware.[16] Studies have shown that these implants, composed of continuous, reinforcing mineral fibers bound with biodegradable polymer matrix, integrate well into bone and provide mechanical properties comparable with metal implants.[10,16,17] Consequently, biointegrative implants may be particularly suited for treating symptoms caused by subchondral bone marrow lesions by adding biomechanical support to the subchondral bone.

The purpose of this study was to evaluate the utility of implanting biointegrative cannulated nails in a rafter arrangement within the tibial plateau or femoral condyle for treatment of subchondral insufficiency of the knee. We hypothesized that this technique would result in reduced postoperative pain and improved patient-reported outcome measures (PROMs), potentially offering an efficient surgical treatment to provide localized stability, support biological repair, and alleviate symptoms in patients with early OA.

Methods

Patients were followed for 12 months after surgical intervention for subchondral insufficiency using bio-integrative, fiber-reinforced fixation nails. This prospective trial was conducted at Midwest Orthopaedics at Rush University Medical Center, which granted institutional review board approval (ORA: 22010201; FWA #: 00000482). All interventions were performed by the senior author (B.J.C.), a fellowship-trained orthopaedic surgeon with a high-volume cartilage restoration practice. Approval was obtained from the local institutional review board before study initiation.

Inclusion criteria were patients aged 18 to 75 years with a body mass index of less than 40 who were experiencing knee pain for at least 6 months with moderate pain on the Knee Injury and Osteoarthritis Outcome Score (KOOS) Pain Scale, unicompartmental Kellgren-Lawrence grade 2-3 OA, and bone marrow lesion confirmed on magnetic resonance imaging (MRI). Exclusion criteria included subchondral bone collapse, bone marrow edema at anterior cruciate ligament or posterior cruciate ligament insertions, tricompartmental OA or severe Kellgren-Lawrence grade 4 OA, inflammatory arthropathies, tobacco use, substance abuse history, high surgical risk, current pregnancy or plans to become pregnant, active or chronic knee infections, need for concomitant procedures (excluding articular cartilage debridement, meniscectomy, microfracture, and loose body removal), and contraindications to MRI (Table 1).

Indication

The technique of implanting biointegrative nails in a subchondral rafter formation was indicated for patients experiencing knee pain for at least 6 months and who had subchondral bone marrow lesions on MRI on either the femoral, tibial, or both sides of the joint. These symptomatic lesions are associated with mechanical overload of the knee and are commonly referred to as subchondral insufficiency.

Intervention

Study intervention involved the surgical implantation of bio-integrative cannulated nails (OSSIOfiber Trimmable Fixation Nails; OSSIO) within the tibial or femoral cortex along the subchondral bone parallel to the articular surface. These nails were placed in a rafter screw-like configuration to provide subchondral support, addressing overload by offering localized stability and promoting biological repair. An intraoperative

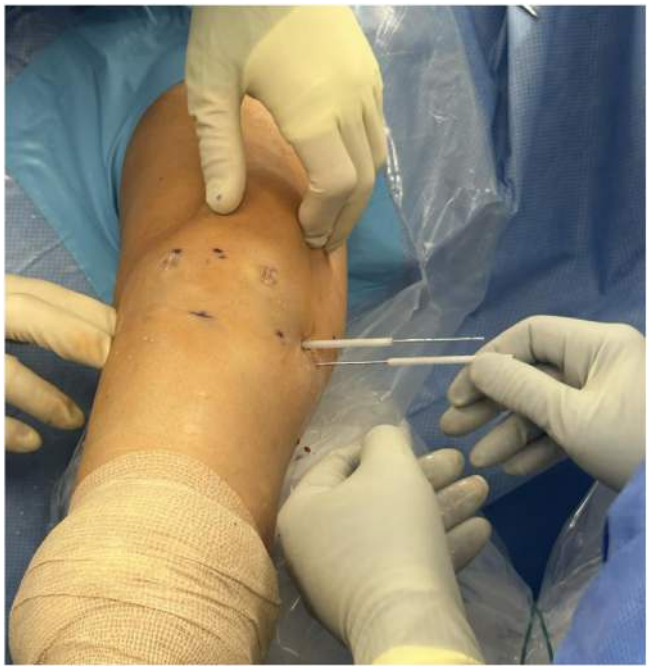

Fig 1. Intraoperative placement of implants. Shown is the placement of 2 biointegrative cannulated trimmable nails percutaneously over guidewires in the proximal tibia.

image showing the placement of implants is shown in Figure 1.

Study Device

The trimmable fixation nails used in this study are biointegrative implants composed of continuous, reinforcing, natural mineral fibers (SiO_2, Na_2O, CaO, MgO, B_2O_3, and P_2O_5; approximately 50%), bound with poly-L-co-D,L-lactic acid polymer matrix (approximately 50%). These implants gradually degrade over approximately 18 to 24 months, facilitating load transfer and supporting bone healing. The biointegrative nature of these implants negates the need for hardware removal surgeries, providing a unique advantage over traditional metal implants. One or two nails are implanted percutaneously in the operating room, with bone marrow lesion targeted with correlation between preoperative MRI in the coronal, axial, and in particular sagittal sequences, with intraoperative fluoroscopy (Fig 2). These are placed under the subchondral plate, and patients are allowed to weight-bear immediately postoperatively without range of motion restrictions.

Outcome Measures

The primary outcome measure was the comparison of baseline and postoperative KOOS for pain. Secondary outcome measures included assessments of PROMs such as International Knee Documentation Committee (IKDC) subjective knee evaluation, Patient-Reported Outcomes Measurement Information System (PROMIS), and Veterans RAND 12-Item Health Survey (VR-12) forms; occurrence of postoperative adverse events and complications; and the time until and incidence of reoperations or additional management outside of postoperative rehabilitation.

In addition, preoperative MRI of the study knee was obtained for all patients in order to calculate lesion volumes. These calculated volumes at the preoperative time point were compared with calculated lesion sizes that were measured at the 12-month time point for each patient. Bone marrow lesion volumes were calculated by applying the formula for the volume of an ellipsoid: volume $= 4/3 \times \pi \times a \times b \times c$, where a, b, and c are the lesion's anteroposterior, transverse, and craniocaudal dimensions measured on sagittal and coronal MRI slices. This method allows for an accurate assessment of the lesion's size and volume to help in tracking its progression and treatment response. The measurements were taken in millimeters and converted to volume using this standard formula, as shown in previous research on subchondral insufficiency fractures of the knee.[18] Examples of preoperative MRI scans used to measure lesions in the study are illustrated in Figure 3.

Follow-Up and Assessments

After the procedure, the patients were allowed full weight-bearing activity and range of motion without a knee immobilizer. Patients underwent follow-up assessments at 3, 6, and 12 months postoperatively. These assessments included clinic visits, noncontrast MRI scans of the study knee, and completion of electronic surveys. The surveys evaluated various PROMs such as KOOS, IKDC, VR-12, PROMIS (Depression, Physical Function, and Pain Interference subsets), and return to sport. The patients completed a course of physiotherapy. Exercises included patellar and tibiofemoral joint mobilization with hamstring, quadriceps, and glute strengthening.

Data Collection and Analysis

A case series that evaluated a natural calcium carbonate implant for similar indications was used for the power analysis.[19] On the basis of the same primary outcome measure, the KOOS Pain score, a sample size of at least 8 patients was calculated to ensure 80% power to detect a difference between baseline and postoperative scores at a significance level of 0.05. To account for an anticipated 20% attrition rate, an initial goal to enroll 10 patients was set preoperatively with aim to collect follow-up data for up to 12 months.

Data were collected through electronic surveys and medical chart reviews. Physical examination data, radiograph series, MRI data, and PROMs were abstracted from patient'' medical records and stored on

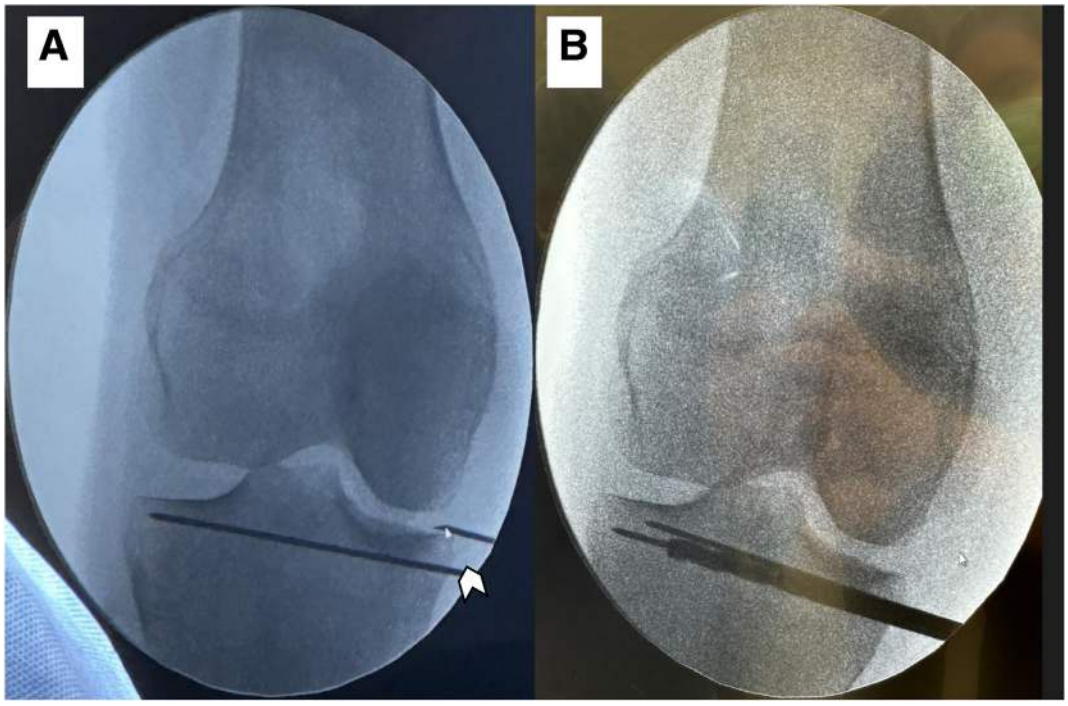

Fig 2. Intraoperative fluoroscopic images. Shown are intraoperative fluoroscopic images showing spinal needle (white arrowhead) submeniscal arthroscopic localization of tibial chondral defect and first guidewire placement rafting the medial and lateral tibial plateau (A) and overdrilling with a cannulated drill for placement of the biointegrative cannulated trimmable nails (B).

an encrypted server requiring 2-factor authentication for access. Baseline and postoperative PROMs were compared using Wilcoxon signed rank test. All statistical tests were 2-tailed, with significance set at $P < .05$. Because of the small sample size, data were not segregated by sex or gender.

Results

Lesion Characteristics and Concomitant Pathology

In total, 9 patients were ultimately enrolled in the study. Three patients had a lesion present in their right knee and 6 had lesions in their left knee. Four patients had exclusive lesions treated at the medial femoral condyle, 2 had exclusive lesions treated at the medial tibial plateau, 1 had a lesion treated at the lateral femoral condyle, 1 had a lesion treated at the lateral tibial plateau, and 1 had lesions at both the medial femoral condyle and the medial tibial plateau that were treated accordingly. Ten lesions were treated in total and included for analysis in this study. Patient information, preoperative lesion locations, concomitant procedures, and orthobiologic augmentation each patient received is presented in Table 2.

Patient-Reported Outcome Measures

The comparison of baseline preoperative and 12-month postoperative KOOS was the primary objective measure used to determine successful management in the patient population. There was a statistically significant improvement in KOOS among the patient population, from a mean score of 53.47 ± 12.37 preoperatively to a mean score of 73.15 ± 20.40 at the 12-month postoperative visit ($P = .008$). The average change from the preoperative to the 12-month time point showed an improvement in score by 19.68. On an individual patient-level analysis, minimal clinically important difference (MCID) achievement was shown in 8 of 9 patients (89%).

Furthermore, the outcomes for the other PROMs associated with pain and physical function (IKDC, PROMIS Pain Interference, PROMIS Physical Function, and VR-12 Physical) also all showed statistically significant improvements. There was an increase in IKDC scores from a mean of 33.85 ± 12.37 preoperatively to a postoperative mean of 62.83 ± 19.39 ($P = .004$) with all 9 patients achieving MCID at 1-year. Figure 4 shows the average change in KOOS and IKDC at 12 months postoperatively for each patient. For PROMIS Pain Interference and PROMIS Physical Function, there were improvement in scores from 62.92 ± 5.03 to 52.56 ± 6.24 ($P = .008$) and 38.31 ± 6.17 to 49.37 ± 7.62 ($P = .008$), respectively. Of the 8 patients who completed both preoperative and postoperative surveys for these measures, 7 (87.5%) achieved MCID for each outcome. Finally, an improvement in VR-12 Physical was shown, with a mean score of 32.85 ± 7.84 preoperatively to a score of 48.98 ± 9.21 at 1-year

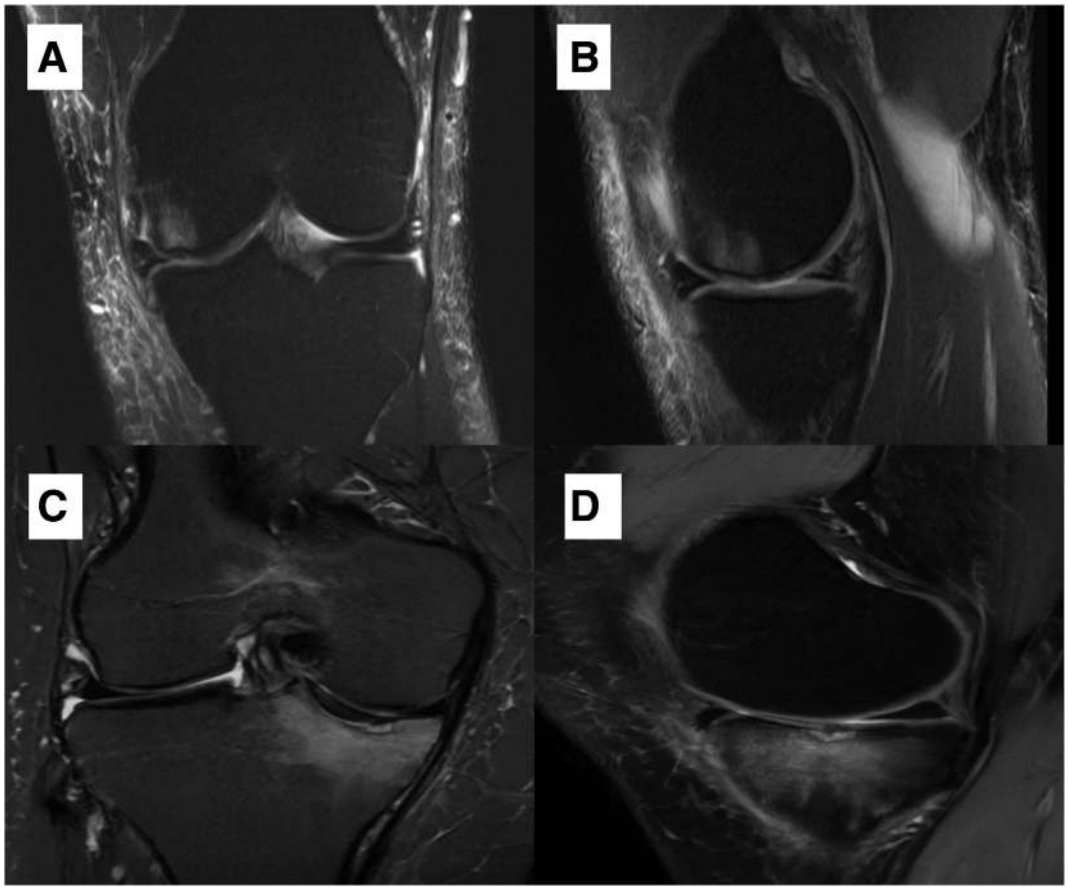

Fig 3. Preoperative MRI showing bone marrow lesions. T2-weighted MRI scans highlighting bone marrow lesions in the medial femoral condyle in the coronal (A) and sagittal (B) planes, along with medial proximal tibial bone lesion localized to the mid-sagittal tibia in the coronal (C) and sagittal (D) planes. (MRI, magnetic resonance imaging.)

postoperatively ($P = .008$) with 7 of 8 patients (87.5%) achieving MCID for this measure as well.

The 2 PROM scores for the evaluation of mental health, PROMIS Depression and VR-12 Mental, both showed a trend toward improvement between preoperative and postoperative scores, but the change was not statistically significant. The PROMIS Depression results showed a change in scores from 45.33 ± 11.48 to 38.70 ± 5.90 ($P = .219$), with 4 of 8 patients (50%) who completed both preoperative and postoperative surveys for this outcome achieving MCID. Similarly, VR-12 Mental increased from 54.50 ± 12.92 to 63.86 ± 3.44 ($P = .313$), with 5 of 8 patients (62.5%) achieving MCID. Patient-reported outcome data are presented in Table 3.

Return to Sport and Work and Complications

Finally, the return to sport and/or work activity was assessed at 12 months postoperatively for each of the individuals in the cohort. Return to sport and work outcomes were reported for all 9 patients, with 100% of respondents reporting favorable return to activity. There were no complications reported in any of the 9 patients at 12-month follow-up.

Imaging Outcomes

Compared with preoperative MRI measurements, 7 of the 10 lesions (70%) measured on 12-month MRI scan showed a decrease in size with an average decrease of 48.94% compared with the original preoperative measurements in this subgroup. When taking each of the 10 lesions of the entire cohort into consideration, however, there was not an overall statistically significant decrease in lesion volume ($P = .064$). The changes from preoperative to 12-month postoperative lesion measurements in each plane and overall lesion volumes are presented in Table 4.

Discussion

The most important finding of this study is that biointegrative nails implanted in a rafter arrangement within the tibial plateau or femoral condyle were effective for the treatment of subchondral insufficiency of the knee. This technique was associated with

Table 2. Patient Demographic Information, Preoperative Lesion Locations, and Concomitant Procedures Performed During Operation

Patient	Sex	Age, yr	Body Mass Index	Laterality	Defect Location	Preoperative Diagnosis	Concomitant Procedures/ Augmentation
1	Female	35	26.6	Left	MFC	Focal defect with subchondral edema	Microfracture; PRP
2	Male	49	34.2	Left	MFC	Medial compartment OA; MM tear; subchondral insufficiency Fx MFC	Medial meniscectomy; articular cartilage debridement
3	Female	36	30.9	Right	LFC	LFC cartilage fissuring	Articular cartilage debridement; cBMA
4	Male	60	38.2	Left	MTP	Patellofemoral, LFC, and MFC OA; MM tear; insufficiency Fx MFC	Medial meniscectomy; articular cartilage debridement
5	Male	61	29.8	Right	MTP	MM tear; insufficiency Fx of posteromedial tibia	Medial meniscectomy; articular cartilage debridement; cBMA
6	Female	39	28.5	Left	LTP	Patellofemoral OA; LM tear; insufficiency Fx LTP	Lateral meniscectomy; articular cartilage debridement
7	Male	46	38	Left	MTP	Insufficiency Fx MFC	Microfracture; cBMA
8	Male	58	25.4	Left	MFC and MTP	Medial compartment OA; MM tear; insufficiency Fx MFC and MTP	Medial meniscectomy; articular cartilage debridement; cBMA
9	Female	64	22	Right	MFC	MM tear; insufficiency Fx MFC	Medial meniscectomy; articular cartilage debridement; cBMA

cBMA, concentrated bone marrow aspirate; Fx, fracture; LFC, lateral femoral condyle; LM, lateral meniscus; LTP, lateral tibial plateau; MFC, medial femoral condyle; MM, medial meniscus; MTP, medial tibial plateau; OA, osteoarthritis; PRP, platelet-rich plasma.

reduced postoperative pain and improved PROMs. There was a statistically significant improvement in the primary outcome measure of KOOS score among the patient population, with 89% achieving clinically significant improvement as measured by MCID. Importantly, the achievement of MCID across multiple PROMs, including a 100% achievement rate for IKDC and 87.5% for PROMIS Pain Interference and Physical Function, shows the meaningful impact of the intervention on patients' daily lives. MCID achievement reflects a threshold of improvement that patients perceive as beneficial, thus underscoring the clinical relevance of the observed changes in PROMs. In addition, significant improvements in IKDC (mean change: 28.99, $P = .004$) and KOOS (mean change: 19.68, $P = .008$) highlight substantial enhancements in knee function, physical capabilities, and quality of life. Although PROMIS Depression and VR-12 Mental scores did not show statistically significant improvements, MCID was achieved by 50% and 62.5% of patients, respectively, suggesting benefit in mental health outcomes for certain individuals.

The impact of concomitant pathology, such as meniscal tears and chondral defects, on clinical outcomes highlights the multifactorial nature of joint degeneration and its treatment. All included patients had at least 1 additional degenerative knee pathology, with meniscal pathology addressed through meniscectomy and chondral defects managed with techniques like microfracture or debridement. These procedures likely contributed to the observed improvements in PROMs by addressing pain and mechanical overload alongside the primary intervention of subchondral raftering.

The biointegrative nail implantation, performed percutaneously in a minimally invasive, extra-articular approach, was hypothesized to provide structural subchondral support without violating the joint surface. This potential biomechanical support may have complemented the effects of meniscectomy, microfracture, or debridement in alleviating mechanical overload and optimizing load distribution. Together, these interventions likely contributed to the observed pain relief and functional recovery, as evidenced by significant improvements in KOOS and IKDC scores and high rates of MCID achievement across PROMs. Compared with alternative joint-preservation options, such as osteochondral allograft transplantation, which involves more invasive intra-articular procedures,[20] subchondral raftering offers a less-invasive solution. The observed

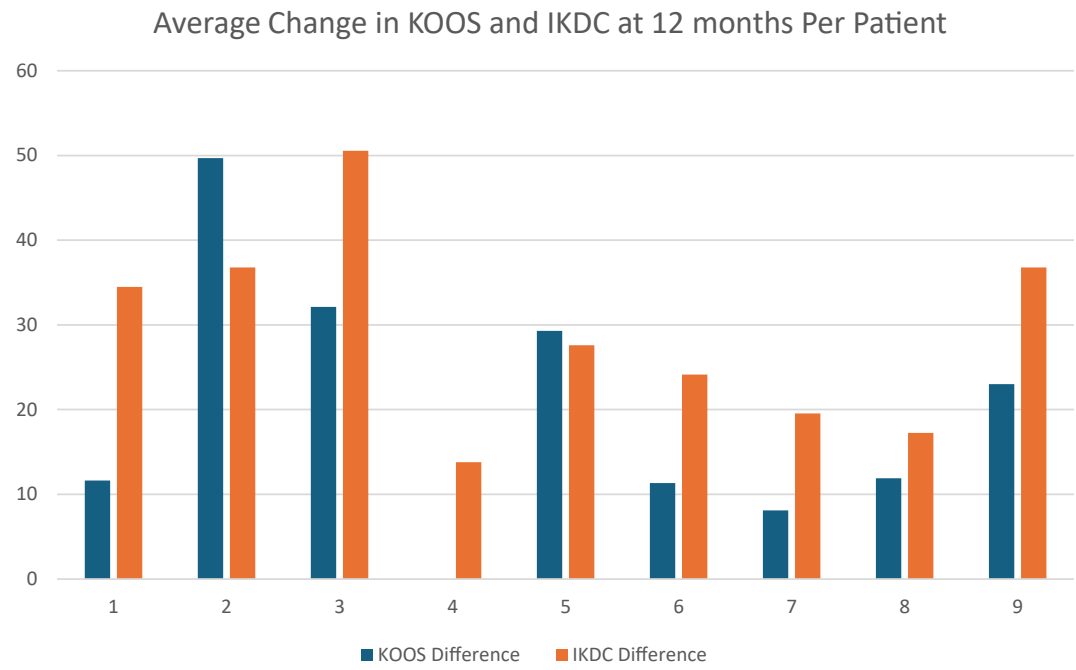

Fig 4. Average change in IKDC and KOOS at 12 months per patient. (IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score.)

improvements in PROMs and MCID achievement underscore the potential benefit of a multifaceted approach in addressing the complex pathology of early OA.

Imaging outcomes, as measured by MRI, showed a reduction in lesion volume in 70% of cases, with an average decrease of 48.94% for this group. Although the overall reduction in lesion volume was not statistically significant when considering all lesions included in the study, the substantial decrease in lesion size in most patients suggests a potentially positive impact of the biointegrative implants on subchondral bone edema. Subchondral bone edema has been shown to correlate with poorer clinical outcomes in knee OA as well as postoperative outcomes after unicompartmental knee arthroplasty, tibial osteotomies, and subchondroplasty.[21-23]

The 0% rate of complications at 12-month follow-up as well as the return to sport or work rate in 100% of patients, further attests to the safety profile and functional benefits of the intervention, allowing patients to resume their daily recreational activities. As a quick procedure in the operating room without significant postoperative rehabilitation and minimal complications, the morbidity or negatives of the procedure are negligible.

Biointegrative fixation implants have been used previously in other areas of orthopaedics. They have shown efficacy in treating foot deformities, offering structural support and promoting biological integration without the need for subsequent removal surgeries.[14-16] More generally, bioabsorbable screws have been used in orthopaedic trauma surgery with promising results and minimal complications, negating the

Table 3. Patient-Reported Outcome Measures at Baseline and at 12-Month Follow-Up

Outcome Measure	Preoperative Mean (SD)	12-Month Postoperative Mean (SD)	*P* value	Mean Improvement	MCID Achievement Percentage, %
KOOS	53.47 (±12.37)	73.15 (±20.40)	**.008**	19.68	89
IKDC	33.85 (±12.37)	62.83 (±19.39)	**.004**	28.99	100
PROMIS Pain Interference	62.92 (±5.03)	52.56 (±6.24)	**.008**	10.35	87.5
PROMIS Physical Function	38.31 (±6.17)	49.37 (±7.62)	**.008**	11.06	87.5
VR-12 Physical	32.85 (±7.84)	48.98 (±9.21)	**.008**	16.14	87.5
PROMIS Depression	45.33 (±11.48)	38.70 (±5.90)	.219	6.63	50
VR-12 Mental	54.50 (±12.92)	63.86 (±3.44)	.313	9.36	62.5

NOTE. *P* values in bold indicate statistical significance at $P < .05$.

IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; PROMIS, Patient-Reported Outcomes Measurement Information System; VR-12, Veterans RAND 12-Item Health Survey.

Table 4. Change in Lesion Measurements From Baseline to 12 Months

Patient	Transverse, cm	Craniocaudal, cm	Anteroposterior, cm	Total Lesion Volume, cm^3
1	−0.016	−0.600	−0.434	−7.790
2	+0.384	−0.149	+0.512	+5.350
3	−0.581	−0.234	−0.098	−3.840
4	−0.455	+0.200	+0.216	+0.040
5	−0.279	−0.418	−0.709	−14.290
6	−0.599	−0.538	+0.183	−10.730
7	+0.264	−0.375	−0.249	−3.720
8 (MFC)	−0.375	+0.004	−0.189	−1.440
8 (MTP)	−0.449	−1.128	−0.875	−1.410
9	+0.365	−0.104	−0.240	+0.950

MFC, medial femoral condyle; MTP, medial tibial plateau.

need for future hardware removal, and have held promise in spine surgery as well.[24,25] The innovation in this study lies in the use of biointegrative nails to manage subchondral insufficiency. This approach leverages the rafter screw-like formation of the nails to aim to provide targeted subchondral support and manage the symptoms of early OA associated with mechanical overload and consequent bone marrow edema. Their structure, composed of mineral reinforcing fibers bound by degradable polymer, may be capable of enabling gradual load transfer and bone healing, offering a more physiologically balanced solution compared with metallic implants.

A key strength of this study is its comprehensive evaluation of clinical outcomes using multiple validated PROMs—such as KOOS, IKDC, PROMIS, and VR-12—and MCID analysis to ensure the improvements observed were both statistically and clinically significant. In addition, the inclusion of patients with concomitant meniscal and chondral deficiencies reflects common clinical scenarios and underscores the multifactorial nature of subchondral insufficiency. Finally, the absence of complications and a 100% return-to-activity rate highlight the safety and functional benefits of the intervention, whereas imaging data provide additional insights into structural changes.

Limitations

This study has several limitations that should be considered when interpreting the results. First, as a pilot, proof-of-concept, and safety study, the small sample size of 9 patients limits the generalizability of the findings. Larger studies are needed to confirm these preliminary results and to provide more robust data on the efficacy of biointegrative cannulated nails for subchondral bone lesions. In addition, the follow-up period of 12 months, although providing valuable short-term data, may not be sufficient to fully assess the long-term outcomes associated with this treatment. Future research with extended follow-up durations will be important to evaluate the sustainability of the improvements observed.

Moreover, the absence of a control group makes it difficult to definitively attribute the observed benefits to the intervention itself, rather than to the effect of concomitant procedures or natural physiological healing. This study included patients with meniscal and chondral deficiencies, reflecting common clinical scenarios where subchondral insufficiency often coexists with other degenerative changes. Although meniscal tears and focal chondral defects were addressed during surgery, these comorbidities may influence joint mechanics and contribute to clinical outcomes. The improvements observed in PROMs likely reflect the combined benefits of subchondral raftering and the concomitant surgical approach employed. Future studies could explore stratification on the basis of specific comorbidities to further delineate the unique contribution of biointegrative implants to symptom relief and functional restoration.

Conclusions

Biointegrative fixation nail raftering for treatment of subchondral insufficiency of the knee resulted in improved patient-reported pain and functionality at 12-month follow-up in the setting of early-to-moderate OA.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: A.S.B. reports board membership with *Arthroscopy*. B.J.C. reports financial support was provided by OSSIO; funding grants from Aesculap AG, JRF Ortho, and National Institutes of Health; board membership with the *American Journal of Sports Medicine*; and *Journal of the American Academy of Orthopedic Surgeons*; consulting or advisory and funding grants from Arthrex and Elsevier; equity or stocks from Bandgrip; equity or stocks from OSSIO; and patents with royalties paid to Arthrex and Elsevier Publishing. All other authors (A.C.W., A.A.Y., J.P.S., S.A.M., R.G.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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