ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Evaluation of Donor Field Morbidity After Mosaicplasty Application in the Healthy Knee Joint

Sağlıklı Diz Ekleminde Mozaikplasti Uygulaması Sonrası Gelişen Donör Saha Morbiditesinin Değerlendirilmesi

Burhan Kurtulus, Hakan Aslan, Osman Yagiz Atli, Halis Atil Atilla, Mutlu Akdogan

Department of Orthopaedics and Traumatology, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Türkiye

ABSTRACT

Aim: *This study investigates the donor site morbidity that develops in patients who received autologous osteochondral grafts from the ipsilateral healthy knee with the Mosaicplasty technique due to talus chondral lesion to investigate its relationship with age, gender, body mass index, number of grafts and diameter.*

Material and Method: *20 patients with talus chondral lesion underwent osteochondral transfer from the same-sided healthy knees using the Mosaicplasty technique. The mean age of the patients at surgery was 36.15; the mean follow-up time was 25.99 months; the mean body mass index was 26.51. The mean graft diameter was 0.87 cm, and the mean number of grafts was 1.5. Lysholm and VAS scores were evaluated. Kellgren-Lawrance classification was used for radiological changes.*

Results: *Donor site morbidity was observed in 4 patients. Two patients had mild knee pain, and one had moderate knee pain. It was observed that the number of grafts taken, age, and body mass index negatively affected Lysholm scores in the final follow-ups after the surgery, and VAS scores were lower in females.*

Conclusion: *In this study, no symptoms were observed in 80% of patients who harvested osteochondral grafts from their healthy knees. However, it is necessary to keep in mind the potential morbidity that may develop in the healthy knee joint after osteochondral transfer to the talus cartilage lesions, especially due to the low Lysholm scores detected in patients over 40 years of age with a body mass index ≥25 and who harvested more than one graft.*

Key words: *articular cartilage lesions; donor-site morbidity; mosaicplasty; osteochondral; knee*

ÖZET

Amaç: *Talus kondral lezyonu nedeni ile aynı taraf sağlıklı dizlerinden Mozaikplasti tekniği ile otolog osteokondral greft alınan hastalarda gelişen donör saha morbiditesinin incelenmesi ve bunun yaş, cinsiyet, vücut kitle indeksi, alınan greft sayısı ve çapı ile olan ilişkisinin araştırılmasıdır.*

Materyal ve Metot: *Talus kondral lezyonu olan toplam 20 hastaya aynı taraf sağlıklı dizlerinden Mozaikplasti tekniği kullanılarak osteokondral transfer işlemi uygulandı. Hastaların cerrahi sırasında ortalama yaşları 36,15, ortalama takip süresi 25,99 ay, ortalama vücut kitle indeksi 26,51 idi. Ortalama greft çapı 1,07 cm, ortalama greft sayısı 1,5 olarak saptandı. Lysholm ve VAS skorları değerlendirildi. Olası osteoartritik değişiklikler için Kellgren-Lawrance sınıflaması kullanıldı.*

Bulgular: *Toplam 4 hastada donör saha morbiditesi gözlendi. İki hastada hafif, bir hastada ise orta derecede diz ağrısı mevcuttu. Hastaların ameliyat sonrası yapılan son kontrollerinde alınan greft sayısı, yaş, vücut kitle indeksindeki artışın Lysholm skorlarını negatif yönde etkilediği, VAS skorlarının ise kadın cinsiyette daha düşük olduğu gözlendi.*

Sonuç: *Bu çalışmada sağlıklı dizlerinden osteokondral greft alınan hastaların %80'inde herhangi bir yakınma gözlenmedi. Ancak özellikle 40 yaş üstü, vücut kitle indeksi ≥25 olan ve birden fazla greft alınan hastalarda saptanan düşük Lysholm skorları nedeniyle talus kıkırdak lezyonlarına osteokondral transfer işlemi sonrası sağlıklı diz ekleminde gelişebilecek potansiyel morbiditenin akılda tutulması gereklidir.*

Anahtar kelimeler: *eklem kıkırdak lezyonları; donör saha morbiditesi; mozaikplasti; osteokondral; diz*

Introduction

Due to the limited spontaneous healing capacity of the avascular and hypocellular structure of the articular cartilage, the surgical treatment of full-thickness cartilage lesions, especially in load-bearing joints, is a clinical problem[1,2]. Arthroscopic debridement of the cartilage lesion, bone marrow stimulation, autologous osteochondral transfer (OOT), and autologous chondrocyte implantation is among the surgical treatments defined in cartilage lesions[1–5]. Although arthroscopic debridement and bone marrow stimulation provide

İletişim/Contact: *Hakan Aslan, Ziraat Mah. Şehit Ömer Halisdemir Cad. No: 20 Dışkapı, 06110 Ankara, Türkiye* • ***Tel:*** *0312 596 22 78* • ***E-mail:*** *draslan50@yahoo.com* • ***Geliş/Received:*** *09.09.2021* • ***Kabul/Accepted:*** *06.07.2022*

ORCID: *Burhan Kurtuluş, 0000-0001-8816-5819* • *Hakan Aslan, 0000-0002-6050-0571* • *Osman Yağız Atlı, 0000-0001-6657-6860* • *Halis Atıl Atilla, 0000-0002-5670-1469* • *Mutlu Akdoğan, 0000-0001-8419-4065*

satisfactory results in the short term, it has been reported that patient satisfaction decreases in the long term[3–5]. In the surgical treatment of full-thickness cartilage lesions, the OOT procedure with the Mosaicplasty technique transfers cylindrical grafts containing living cartilage tissue from the intact cartilage area subchondral bone tissue under it to the damaged cartilage area[2,5–7]. In this technique, the knee joint is the most preferred joint for the donor site, and the medial and lateral trochlear non-load-bearing parts of the femoral condyle are ideal areas for graft harvesting[2,5,8]. After the graft is taken, healing is observed in the donor site with cancellous bone underneath and fibrocartilage-like tissue on the joint surface[8,9]. Although it is seen as an important advantage of the Mosaicplasty technique as it allows living cartilage tissue to be transported to the damaged area with a single-stage surgical procedure, complaints such as pain, patellofemoral problems, effusion, crepitation, instability, i.e., donor site morbidity (DSM) in the donor site is a majordisadvantage[2,6,10].

In this study, we aim to examine DSM that developed in patients who received autologous osteochondral grafts with the Mosaicplasty technique from ipsilateral healthy knees due to talus chondral lesion and to investigate the relationship of this morbidity with age, gender, body mass index (BMI), number of grafts and diameter.

We hypothesize that DSM will increase as the number of grafts taken from the donor site or an increase in graft size; an increase in BMI and age negatively affect clinical outcome scores, and gender will not affect DSM.

Material and Method

After the local ethics committee decision with the number 28.06.2021–114/11 and the name of 'retrospective analysis of donor site morbidity after mosaicplasty application in the healthy knee joint,' we retrospectively studied a series of 24 patients who harvested osteochondral autografts from their ipsilateral intact knees for the surgical treatment of symptomatic talus osteochondral lesion between January 2016 and November 2020. Thirteen of the patients were male, and 11 were female. Inclusion criteria of patients in the study:

1. Patients with a follow-up period of at least six months,
2. Patients who have not had previous surgery on the knee to which osteochondral transfer was performed and who do not have any knee complaints,
3. Patients with regular follow-up, sufficient data, and knee radiographs of sufficient quality.

A total of 4 patients were excluded from the study, two of whom did not come for regular follow-up and two whose radiographs were not of sufficient quality. Thus, 20 patients, ten men and ten women were included in the study. The mean age of the patients at the time of surgery was 36.15 (19–54), and the mean follow-up period was 25.99 months (6 months-64 months). The mean BMI of the patients was 26.51 (22.21–37.46). Graftharvestingwas performed from the right knee in eight patients and from the left knee in twelve patients (Table 1).

Arthrex (Arthrex, Naples, FL) press-fit OOT system was used for graft harvesting from the donor site in all patients. This system allows 6, 8, 10 and 12 mm osteochondral cylindrical grafts to be taken from the donor site. For osteochondral graft harvesting, lateral parapatellar arthrotomy was used in all patients, and areas adjacent to the trochlear part of the ipsilateral lateral femoral condyle were preferred (Fig. 1). One autologous graft was harvested in 10 patients and two autologous grafts in 10 patients. In all patients, the recipient area was the talus superomedial articular surface in the ipsilateral ankle joint. Chevron-type osteotomy was applied to the medial malleolus in all patients to reach the medial cartilage lesion to the talus. The recipient area, where the cartilage defect on the talus joint surface is located, was prepared with the help of a cannulated reamer by the diameter and length of the osteochondral graft taken from the femur, and the graft taken from the donor area was impacted on the recipient area. Two 4.0 mm cannulated screws were used to fix the medial malleolus. The defect formed in the donor site was filled with subchondral bone obtained from the recipient site (Fig. 2). A 24-hour hemovac drain was used for the knee joint in all patients postoperatively. Movement exercises were started after the drains were removed. Complete weight-bearing restriction was applied to the patients for the first six weeks after surgery. In the following period, they were allowed to weigh as much as they could tolerate. No postoperative infection was observed in any patient. One patient observed hemarthrosis in the knee joint on the 2nd postoperative day. This patient was treated by aspiration and cryotherapy. In the postoperative 1-month follow-up of the patient, it was noted that the swelling in the knee joint was minimized. All patients had a minimum 6-month follow-up.

Knee flexion-extension intervals were detected in the clinical examinations for the knee joints at the final

Table 1. *Patient demographics*

	Minimum	Maximum	Average	Std. deviation
Age	19	54	36.15	±11.69
Weight (kg)	58	110	78.90	±11.98
Length (cm)	155	191	172.65	±11.34
BMI	22.21	37.46	26.51	±3.83
Follow up period (mo)	6	64	25.99	±12.17

Figure 1. *Donor field image after graft removal.*

Figure 2. *Donor site image before surgical site closure.*

controls. Lysholm and VAS (Visual Analog Scale) scores were evaluated. In the radiological examination, possible osteoarthritic changes were recorded on the knee's anteroposterior, lateral and tangential patella radiographs.

Data were recorded on the computer, and Statistical Package for Social Sciences version 22 (SPSS Inc., Chicago, IL, USA) was used for biostatistical analysis. The Mann-Whitney U test compared means. The level of significance was set at $p<0.05$.

Results

Lysholm score was accepted as 100, and VAS score for knee joints was accepted as 0 since no patient had any problems and complaints in the preoperative knee clinical examinations. The mean postoperative Lysholm score of the patients was recorded as 83.25 (29–100). The mean postoperative VAS score of the patients was 2.55. When Lysholm scores were evaluated, excellent results were obtained in 10 patients (95–100), good results in 4 patients (84–94), intermediate results (83–65) in 3 patients, and poor results (<65) in 3 patients. The mean American Foot and Ankle Score was 51.05 (29–68) before the operation, while 89.35 (72–100) postoperatively.

When the knee flexion and extension ranges of the patients were evaluated, no limitation was observed in any of the patients. In the examination of knee complaints at the final follow-ups after the surgery, two patients had knee pain, one had knee joint effusion, and one had a locking sensation. Three of these patients were female, and one was male. The first of the patients with knee pain started by walking about 500 m, and the other patient had pain especially by pressing on the lateral condylar region of the femur. On the other hand, the patient who complained of locking sensation had problems, especially during stair climbing and squatting movements.

Patients were divided into two groups with BMI below 25 and above. There were nine patients with BMI <25 in the first group and 11 patients with a BMI ≥25 in the second group. When the VAS scores for knee pain were evaluated, the mean postoperative VAS score was 1.11 (0–2) in the first group and 3.73 (0–7) in the second group. The difference was not statistically significant. ($p=0.529$) While the mean postoperative Lysholm score was 94.0 (79–100) in the patients in the first group, this value was 74.45 (29–100) in the second group. The difference was statistically significant ($p=0.031$) (Table 2).

Patients were divided into two groups according to the number of grafts harvested from the lateral condyle of the femur. Ten patients with one graft number were in the first group, and ten patients with two grafts were in the second group. The mean postoperative Lysholm score was 91 (43–100) in the first group and 73.20 (29–83) in the second group. The difference was statistically significant. ($p=0.035$) While the mean postoperative VAS score was 1.40 (0–3) in the first group, it was 3.70 (0–7) in the second group. The difference was statistically insignificant ($p=0.089$) (Table 3).

Patients were divided into two groups according to the diameter of the graft harvested from the donor site. Ten patients with a graft diameter of less than 1 cm were in the first group, and ten patients with a graft diameter of 1 cm or more were in the second group. The mean postoperative Lysholm score was 77.30 (29–100) in the first group and 89.20 (71–100) in the second group. The difference was not statistically significant. ($p=0.481$) While the mean postoperative VAS score was 2.90 (0–7) in the first group, it was 2.20 (0–6) in the second group. The difference was statistically insignificant ($p=0.684$) (Table 4).

When the relationship between age with VAS and Lysholm scores was evaluated, the mean VAS score after surgery was found to be 1.80 (0–6) in patients younger

than 40 years of age (n: 10) and 3.30 in patients over 40 years of age (n: 10). It was observed that the difference was not statistically significant. (p=0.105) Lysholm score was 94.70 (77–100) preoperatively and 71.80 (29–96) postoperatively. The difference was statistically significant. (p=0.004) (Table 5).

Next, the relationship between gender and postoperative VAS and Lysholm scores was examined. The mean postoperative VAS score was 3.70 (1–7) in female patients, while it was 1.40 (0–3) in male patients. The difference was statistically significant. (p=0.019). Lysholm score was 73.40 (29–100) in women and 93.10 (71–100) in men after surgery. The difference was statistically significant (p=0.043) (Table 6).

The patients were not evaluated for knee osteoarthritis preoperatively but did not complain of knee pain. When the anteroposterior and lateral knee radiographs and tangential patella radiographs taken at the last follow-up of the patients were evaluated according to the Kellgren-Lawrance classification, it was found that 17 patients had stage 0, 2 patients had stage 1 (asymptomatic), and one patient had stage 2 osteoarthritis. A male patient with Kellgren-Lawrance Stage 2 osteoarthritis had a 56-month follow-up period, and osteophytes were located on the lateral patella.

Discussion

The most important finding of this study was that increasing the number of autologous grafts taken from the femoral area and increasing values of age and BMI negatively affected the Lysholm knee score. In addition, it was observed that the number of grafts taken after the surgery, diameter, BMI, and age increase did not affect the VAS score negatively. Still, the female gender negatively affected the VAS score.

A limited number of publications in the literature investigating DSM development after graft removal from a healthy knee. Nakagawa et al. reported that 85% of patients who harvestedosteochondral grafts from a healthy knee are asymptomatic[8]. Matsuura et al.[11] emphasized that the DSM rate increased to 2.3% when the general criteria were applied, but it increased to 12.8% when the sharper criteria were used; in the mosaicplasty procedure, they applied from the healthy knee in juvenile athletes with capital osteochondritis dissecans. Paul et al.[12] reported that five of 112 patients were moderately dissatisfied with their knees and six were severely dissatisfied with their knees in a large-series cohort study in which they had osteochondral lesions of the talus and applied mosaicplasty and followed up for more than two years. Nishimura et al.[13] found weakness in the knee extensor strength compared to the other knee in 8 of 11 patients they transferred from the intact opposite knee

Table 2. *VAS and Lysholm scores according to body mass index*

BMI		VAS	Lysholm
BMI <25	Average	1.11	94
	Std. deviation	±0.601	±6.856
	Minimum	0	79
	Maximum	2	100
BMI ≥25	Average	3.73	74.45
	Std. deviation	±2.102	±23.058
	Minimum	0	29
	Maximum	7	100
	p	0.529	0.031

Table 3. *VAS and Lyshholm scores by number of grafts*

Number of plugs		VAS	Lysholm
1	Average	1.40	93.30
	Std. deviation	±0.843	±8.908
	Minimum	0	70
	Maximum	3	100
2	Average	3.7	73.20
	Std. deviation	±2.312	±23.213
	Minimum	0	29
	Maximum	7	100
	p	0.089	0.035

Table 4. *VAS and Lyshholm scores according to graft diameter*

Graft Diameter		VAS	Lysholm
Diameter of plugs <1 cm	Average	2.90	77.30
	Std. deviation	±2.424	±25.613
	Minimum	0	29
	Maximum	7	100
Diameter of plugs ≥1 cm	Average	2.20	89.20
	Std. deviation	±1.687	±10.390
	Minimum	0	71
	Maximum	6	100
	p	0.684	0.481

Table 5. *VAS and Lyshholm scores by age*

Age		VAS	Lysholm
Age <40	Average	1.80	94.70
	Std. deviation	±1.751	±7.528
	Minimum	0	77
	Maximum	6	100
Age ≥40	Average	3.30	71.80
	Std. deviation	±2.163	±22.240
	Minimum	1	29
	Maximum	7	96
	p	0.105	0.004

Table 6. *VAS and Lyshholm scores by gender*

Gender		VAS	Lysholm
Female	Average	3.70	73.40
	Std. deviation	±2.214	±23.396
	Minimum	1	29
	Maximum	7	100
Male	Average	1.40	93.10
	Std. deviation	±1.075	±8.925
	Minimum	0	71
	Maximum	3	100
	p	0.019	0.043

for the osteochondral lesion in the humerus capitellum. Still, they stated that all patients reached preoperative knee strength within the first year after the surgery.

Pain, effusion, patellofemoral problems, limitation of movement, crepitation, and locking sensation are among the most important causes of DSM in the knee joint after osteochondral graft harvesting[2,8,10,11,13–15]. Andrade et al.[2] stated that the most common DSM observed in mosaicplasty applied from the knee to the ankle is pain and instability observed during daily or sports activities. Bexkens et al.[14] found the most common pain (7.8%) and locking sensation (0.8%) during daily activities in patients who applied osteochondral transfer to the humerus capitellum from the healthy knee. Valderrabano et al.[15] reported knee pain in 6 (50%) of 12 patients who underwent mosaicplasty for an osteochondral lesion of the talus in the knee joint. The current study observed DSM in 4 patients (20%).

Two grafts were harvested from the lateral condyle of the femur in one of the two patients with knee pain. In the other patient, the graft diameter was 1 cm. The first of the patients with knee pain started by walking about 500 m, and the other patient had pain especially by pressing on the lateral condylar region of the femur. The patient who developed hemarthrosis in the knee also had two grafts of 1 cm from the knee. It was observed that the postoperative swelling of the patient, for whom aspiration, cryotherapy, and elevation were applied, was minimized and did not affect the knee functions. The other patient complained of a locking sensation and described stuttering in the knee, especially during stair climbing and squatting movements. This patient underwent diagnostic arthroscopy at six months postoperatively. During the arthroscopic procedure, it was observed that the fibrocartilage-like tissue grew excessively in the grafted area. Following the shaving of the overgrown tissue, it was observed that the complaints of locking sensation were resolved at the last control of the patient.

When the relationship between DSM and age was investigated: Woelfle et al.[16] found a significant decrease in Hospital for Special SurgeryPatella scores in patients over 40. Al-Skaikh et al.[17] also reported that Lysholm scores in patients under 30 years of age were significantly better than those over 30. In contrast, Reddy et al. said that they did not detect a relationship between DSM with age[18]. The current study determined that Lysholm scores in patients under 40 years of age were significantly better than those over 40 years of age. Seven female and three male patients in the study group were over 40 years old. The VAS scores were worse in the patients over 40, but the difference was not statistically significant.

Regarding the relationship between DSM and age, Paul et al. indicate that the increase in BMI negatively affects Lysholm and WOMAC scores in patients undergoing osteochondral transfer to the ankle and that Lysholm score is more sensitive in terms of showing symptoms that occur in the early postoperative period, as it focuses on knee functions[12]. Matsuura et al.[11] argue that the patient populations are very young and have a low BMI, which may have led to DSM at a low rate of 2.3%. Similarly, Kim et al. report that patients with a BMI lower than 26 have a lower DSM and a higher Tegner activity score[19]. However, Woelfle et al. interpret that the VAS score is lower and the AOFAS score is higher in patients with a BMI above 25, probably due to the lower expectation of physical activity in this patient group[16]. In the current study, while the Lysholm score was 74.45 in patients with BMI ≥25, this value was 94 in patients with a BMI ≥25. This statistically significant value is important in terms of showing that postoperative knee functions can be negatively affected in overweight patients. We think the different pain thresholds can explain the statistically insignificant post-operative mean VAS values in both groups in each patient and the subjective nature of VAS values.

Studies published with different results regarding the relationship between diameter and number of tubular grafts harvested from the femoral condyle and DSM. Reddy et al. did not find a relationship between the number and diameter of grafts taken and DSM[18]. The same result was reported by Andrade et al.[2] and Paul et al.[12] Al-Shaikh et al.[17] said knee scores were worse in patients who received two grafts than those who received one graft. In their experimental studies on cadaver knees, Guetller et al.[20] showed that donor site defects up to 5 mm created in the periphery of the lateral femoral condyle in the upper part of the sulcus terminalis were not affected by patellar contact pressure. They also believe that additional lateral release may be meaningful in reducing the pressure this region is exposed to, so that lateral release may be preferred in larger donor site defects. In the current study, a single graft was taken in 10 patients, and two grafts were taken in 10 patients. It was observed that Lysholm scores were lower in patients with large graft diameters, but VAS scores were not affected by the number of grafts taken and the diameter of the graft.

When the effect of gender on DSM was examined, it was found that both Lysholm and VAS scores were lower in female patients. We think that the possible reason for this may be because there are seven female patients over the age of 40, and 6 (85%) of these patients have a BMI of ≥25.

This study includes some limitations. First, the study is retrospective. Second, the post-surgical donor site could not be evaluated with MR images or arthroscopically (except for one patient who underwent diagnostic arthroscopy after surgery). Third, our follow-up period is short to observe osteoarthritic changes that may develop in the donor site. The fourth is that the number of our patients is relatively small.

The study's strength is that it is the first study in our country to investigate the relationship of DSM with osteochondral graft diameter, number, BMI, age, and gender in OOT application from the ipsilateral healthy knee in talus chondral lesions.

Conclusion

In conclusion, in the surgical treatment of cartilage problems in load-bearing joints, OOT with the Mosaicplasty technique is a preferred method in that it can be applied with a single-stage surgery and allows the transfer of living cartilage tissue. In this study, the good and excellent results that we obtained in 17 patients in the transfer of osteochondral graft taken from the knee joint to the talus cartilage lesion for talus chondral lesions demonstrate the effectiveness of the OOT system. However, the Lysholm score decreases as the number of grafts taken from the knee joint, BMI, and age increases. Therefore the observation of DSM is among the undesirable effects of the system. Therefore, morbidity and osteoarthritic changes that may occur in the healthy knee joint after OOT for talus cartilage lesions should be kept in mind.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject nor from a company that provides or produces medical instruments and materials, which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, shareholding, and similar situations in any firm.

Authorship Contributions

Idea/Concept: H.A, O.Y.A; Design: B.K, M.A; Control/Audit: H.A.A, O.Y.A; Data Collection and/or Processing: O.Y.A, B.K; Analysis and/or Interpretation: M.A, H.A.A; Writing the Article: H.A, B.K; Critical Review: O.Y.A, H.A.A; Sources: H.A, M.A.

References

1. De l' Escalopier N, Barbier O, Mainard D, Mayer J, Ollat D, Versier G. Outcomes of talar dome osteochondral defect repair using osteocartilaginous autografts: 37 cases of Mosaicplasty®. Orthop Traumatol Surg Res. 2015;101(1):97–102.
2. Andrade R, Vasta S, Pereira R, Pereira H, Papalia R, Karahan M, et al. Knee donor-site morbidity after mosaicplasty - a systematic review. J Exp Orthop. 2016;3(1):31.
3. Ferkel RD, Zanotti RM, Komenda GA, Sgaglione NA, Cheng MS, Applegate GR, et al. Arthroscopic Treatment of Chronic Osteochondral Lesions of the Talus. Am J Sports Med. 2008;36(9):1750–62.
4. Laffenêtre O. Osteochondral lesions of the talus: Current concept. Orthop Traumatol Surg Res. 2010;96(5):554–66.
5. Hangody L, Vásárhelyi G, Hangody LR, Sükösd Z, Tibay G, Bartha L, et al. Autologous osteochondral grafting-Technique and long-term results. Injury. 2008;39(1):32–39.
6. Iwasaki N, Kato H, Kamishima T, Suenaga N, Minami A. Donor Site Evaluation after Autologous Osteochondral Mosaicplasty for Cartilaginous Lesions of the Elbow Joint. Am J Sports Med. 2007;35(12):2096–100.
7. McCoy B, Miniaci A. Osteochondral Autograft Transplantation/ Mosaicplasty. J Knee Surg. 2012;25(02):099–108.
8. Nakagawa Y, Mukai S, Setoguchi Y, Goto T, Furukawa T, Nakamura T. Clinical Outcomes of Donor Sites After Osteochondral Graft Harvest from Healthy Knees. Orthop J Sports Med. 2017;5(10).
9. Bedi A, Feeley BT, Williams RJ. Management of Articular Cartilage Defects of the Knee. J Bone Joint Surg Am. 2010;92(4):994–1009.
10. Shimozono Y, Seow D, Yasui Y, Fields K, Kennedy J G. Knee-to-Talus Donor-Site Morbidity Following Autologous Osteochondral Transplantation. Clin Orthop Relat Res. 2019;477(8):1915–31.
11. Matsuura T, Hashimoto Y, Kinoshita T, Nishino K, Nishida Y, Takigami J, et al. Donor Site Evaluation After Osteochondral Autograft Transplantation for Capitellar Osteochondritis Dissecans. Am J Sports Med. 2019;47(12):2836–43.
12. Paul J, Sagstetter A, Kriner M, Imhoff A, Spang J, Hinterwimmer S. Donor-Site Morbidity After Osteochondral Autologous Transplantation for Lesions of the Talus. J Bone Joint Surg Am. 2009;91(7):1683–88.
13. Nishimura A, Morita A, Fukuda A, Kato K, Sudo A. Functional Recovery of the Donor Knee After Autologous Osteochondral Transplantation for Capitellar Osteochondritis Dissecans. Am J Sports Med. 2010;39(4):838–42.
14. Bexkens R, Ogink PT, Doornberg JN, Kerkhoffs GMMJ, Eygendaal D, Oh LS, et al. Donor-site morbidity after osteochondral autologous transplantation for osteochondritis dissecans of the capitellum: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2017;25(7):2237–46.
15. Valderrabano V, Leumann A, Rasch H, Egelhof T, Hintermann B, Pagenstert G. Knee-to-Ankle Mosaicplasty for the Treatment of Osteochondral Lesions of the Ankle Joint. Am J Sports Med. 2009;37(1 Suppl):105–111.
16. Woelfle JV, Reichel H, Nelitz M. Indications and limitations of osteochondral autologous transplantation in osteochondritis dissecans of the talus. Knee Surg Sports Traumatol Arthrosc. 2013;21(8):1925–30.
17. Al-Shaikh RA, Chou LB, Mann JA, Dreeben SM, Prieskorn D. Autologous Osteochondral Grafting for Talar Cartilage Defects. Foot Ankle Int. 2002;23(5):381–89.
18. Reddy S, Pedowitz DI, Parekh SG, Sennett BJ, Okereke E. The Morbidity Associated with Osteochondral Harvest from Asymptomatic Knees for the Treatment of Osteochondral Lesions of the Talus. Am J Sports Med. 2007;35(1):80–85.
19. Kim YS, Park EH, Kim YC, Koh YG, Lee JW. Factors Associated with the Clinical Outcomes of the Osteochondral Autograft Transfer System in Osteochondral Lesions of the Talus. Am J Sports Med. 2012;40(12):2709–19.
20. Guettler JH, Demetropoulos CK, Yang KH, Jurist KA. Dynamic Evaluation of Contact Pressure and the Effects of Graft Harvest with Subsequent Lateral Release at Osteochondral Donor Sites in the Knee. Arthroscopy. 2005;21(6):715–20.