Research Article / Araştırma Makalesi

Results of Vascularized Bone Graft Application in The Kienböck Disease

Kienböck Hastalığında Vaskülarize Kemik Grefti Uygulamasının Sonuçları

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Abstract

Background: We aimed to evaluate the postoperative clinical and radiological results of Kienböck patients treated with extensor compartmental artery pedicled vascularized bone graft (VBG).
Materials and Methods: In this study, 12 patients who were diagnosed with Kienböck's disease and underwent revascularization (with pedicled VBG from distal radius) and attended at least one postoperative follow-up between January 2011 and June 2015 in Harran University, Department of Orthopedics and Traumatology. In the follow-up, clinical evaluation was performed with Visual Analog Scale (VAS), Modified Mayo Wrist Score (MMWS) and Quick Disabilities of the Arm, Shoulder and Hand Questionnaire (Q-DASH).
Results: Seven of the cases were female (58.3%) and 5 of them were male (41.7%). Mean age was 27.83. Seven (58.3%) of the cases were on the right, while 10 (83.3%) were on the dominant wrist. Trauma history was not found in 9 (75%) cases. After the operation, the MMWS result was good / excellent in 11 (91.7%) patients, and the Q-DASH score of these patients was between 5-20. Nine (75%) patients had a VAS score of 2 or lower. In both preoperative and postoperative evaluation, we determined negative ulnar variance in 9 (75%) and neutral ulnar variance in 3 (25%) cases (no positive ulnar variance). Significant changes in postoperative Stahl index were not determined. Preoperative flexion and extension range of motion values had increased significantly at postoperative measurements ($p < 0.05$). When compared with the preoperative values, it was determined that postoperative carpal height ratio decreased significantly, and wrist grip strength increased significantly. Postoperative scintigraphy was performed in 11 cases. Osteoblastic activity was detected in 10 cases. The MRI results of these 10 cases showed findings in favor of revascularization in 5 patients.
Conclusions: The use of pedicled VBG for the treatment of Kienböck's disease is very successful in providing revascularization and restoring functionality. Revascularization was detected in scintigraphy in all but 1 patient, while MRI showed it in 5 patients. Treatment-specific results can be explored in more detail with a higher number of patients diversified according to surgical approach. Such efforts will be helpful in determining appropriate options in the treatment of Kienböck's disease.

Key Words: Lunate, Kienböck's Disease, Bone Graft

Öz.

Amaç: Ekstansör kompartmanlı arter pediküllü vaskülarize kemik grefti (VBG) ile tedavi edilen Kienböck hastalarının postoperatif klinik ve radyolojik sonuçlarını değerlendirmeyi amaçladık.
Materyal ve Metod: Bu çalışmada, Ocak 2011-Haziran 2015 tarihleri arasında Harran Üniversitesi Ortopedi ve Travmatoloji Anabilim Dalı'nda Kienböck hastalığı tanısı alan ve revaskülarizasyon (distal radiustan pediküllü VBG ile) yapılan ve en az bir postoperatif takibi bulunan 12 hasta çalışmaya dahil edildi. İzlem sırasında bu hastalara Görsel Analog Skala (VAS), Modifiye Mayo Bilek Skoru (MMWS) ve (Q-DASH) anketi ile klinik değerlendirme yapıldı.
Bulgular: Olguların 7'si kadın (% 58,3), 5'i erkek (% 41,7) idi. Ortalama yaş 27.83 idi. Olguların yedisi (% 58,3) sağda, 10'u (% 83,3) dominant bilekte idi. Dokuzunda (% 75) travma öyküsü bulunamadı. Ameliyat sonrası 11 (% 91,7) hastada MMWS sonucu iyi / mükemmeldi ve bu hastaların Q-DASH skoru 5-20 arasında idi. Dokuz (% 75) hastanın VAS skoru 2 veya daha düşüktü. Hem preoperatif hem de postoperatif değerlendirmede 9 (% 75) vakada negatif ulnar varyans ve 3 (% 25) vakada nötr ulnar varyans (pozitif ulnar varyans yok) belirledik. Postoperatif Stahl endeksinde önemli değişiklikler tespit edilmedi. Preoperatif fleksiyon ve ekstansiyon hareket açıklığı değerleri postoperatif ölçümlerde anlamlı olarak arttı ($p < 0.05$). Preoperatif değerler ile karşılaştırıldığında postoperatif karpal yükseklik oranının anlamlı olarak azaldığı ve bilek kavrama gücünün anlamlı olarak arttığı belirlendi. 11 vakada postoperatif sintigrafi yapıldı. 10 vakada osteoblastik aktivite tespit edildi. MRG sonuçları 5 hastada revaskülarizasyon lehine bulgular göstermiştir.
Sonuç: Kienböck hastalığının tedavisi için pediküllü VBG kullanımı revaskülarizasyon sağlamada ve işlevselliği geri kazanmada çok başarılıdır. Sintigrafide 1 hasta dışında hepsinde revaskülarizasyon tespit edilirken, MRG'da 5 hastada ravaskülarizasyon bulguları saptandı. Cerrahi yaklaşıma göre çeşitlendirilmiş daha fazla sayıda hasta ile tedaviye özgü sonuçlar daha detaylı araştırılabilir. Bu tür araştırmalar, Kienböck hastalığının tedavisinde uygun seçeneklerin belirlenmesinde yardımcı olacaktır.

Anahtar kelimeler: Lunate, Kienböck hastalığı, Kemik grefti

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Introduction

The wrist is a highly mobile and complex structure consisting of eight carpal bones and ligaments. The carpal bones show two separate sequences, distal and proximal. The second bone from the lateral to the medial in the proximal alignment is the lunate(1).

Kienböck's disease (Lunatomalacia) is a of avascular necrosis of the lunatum, causing progressive pain and loss of function in the wrist joint (2). This condition is called Kienböc'k's disease. It is generally seen in adults before the age of 40, mostly occurs in men, and is usually unilateral and on the dominant side(3, 4).Although many variables such as , overloading, blood supply problems, recurrent traumas, and shape and position disorders are investigated in the development of Kienböck'sdisease, a direct etiological cause has not been clearly determined (5, 6). In patients, decreased grip strength, restricted joint movements and pain are the main findings(7). Since Kienböck's disease is a disease that starts with the deterioration in the architecture of the lunate and results in wrist arthrosis, it is considered as a problem that concerns not only the lunate pathology but also the entire wrist(8).

Since there is no consensus on the etiology of the disease, there is no gold standard option for treatment(9, 10).While immobilization and conservative treatment are preferred in the early stages, surgical procedures can be applied in cases where the disease keeps progressing and there is no response to conservative treatment(11-13). Similarly, since the etiology is not clear,the application and approach to surgical intercentions also vary (5, 14).for example, conservative treatment,epiphysiodesis, radial ostetomy and revascularization procedures are the main ones(11-13, 15-19).Today, vascular bone grafts (VBG) are among the most preferred and popular approaches in the treatment of Kienböck's disease (20-22).Revascularization using apedicled VBG from the distal region of the radius is an important treatment option, as various studies examining the results of this method have shown very successful functional and radiological results (23-26).

Although there are previous studies reporting the radiological and clinical results of the use of pedicled VBG in the treatment of Kienböck's disease, it is noteworthy that the number of studies investigating this issue are few and these studies include limited patient numbers (due to the rarity of the disease). Thus, data concerning clinical characteristics and treatment outcomes are limited. In this study, we aimed to evaluate the postoperative clinical and radiological results of Kienböck patients treated with extensor compartmental artery (ECA) pedicled VBG.

Materials and Methods

Patient population

In this study, 12 patients who were diagnosed with Kienböck'sdisease and underwent revascularization with a pedicled VBG from the distal radius, between January 2011 and June 2015 at Department of Orthopedics and Traumatology were included.All patients. had attended postoperativefollow-up at least once after surgery. Ethics committee approval was obtained from the Ethical Committee of the Medical Faculty at Harran University (decision number :15/07/05).

The patients were followed up for an average of 20 months. Clinical evaluation was performed with the Visual Analog Scale (VAS), Modified Mayo Wrist Score (MMWS) and Quick Disabilities of the Arm, Shoulder and Hand Questionnaire (Q-DASH). Radiological evaluation was performed by magnetic resonance imaging (MRI) and technetium bone scintigraphy. Anamnesis, physical examination, direct radiography and MRI were used as diagnostic methods. After the vascularized graft surgery was appropriately explained to patients, we obtained informed consent for the procedure and also inclusion into the study.All patients underwent necessary consultations and differential diagnosis before surgeries were planned. Patients were admitted to our ward on the day of their scheduled surgery for preliminary tests, after anesthesia proceduresthey were taken to the operating room for surgical intervention.

Surgical procedure

Under the turnstile in the supine position, the skin and subcutaneous tissue were passed via a dorsal longitudinal incision over the 4th and 5th extensor compartments of the wrist. After defining the extensor retinaculum, the joint capsule was lifted over the lunate in the form of a radial-based flap and access to the lunate bone was obtained. Concurrently, the artery and vein were detected in the 5th extensor compartment. This pedicle was preserved and followed up proximally. The site where it branched from the anterior interosseous artery was determined, and the 5th ECA was mobilized to the point where it was branched from the anterior interosseous artery and it was ligated from this point. The 4th ECA was found on the compartment and was followed proximally, and the artery was freed from the surrounding soft tissues by locating the branch from the 5th ECA (Figure 1). Approximately 1 cm proximally from the joint, the region where the 4th ECA entered the bone was determined. A sufficient bone graft was taken along with the artery and a pedicle bone graft was obtained (Figure 2).Finally, after cleaning and clearing the defective parts of the lunate, the pedicled bone graft was placed vertically and was tightly wedged into the gap created for the graft (27).

Follow-up investigations

In the postoperative follow-up, direct radiographs (X-rays) of the patients were taken and their clinical examinations were performed. Imaging studies with MRI and bone scintigraphy were planned for the 12th month. However, due to patient incompatibility, standardization on MRI, scintigraphy and x-ray timing was not achieved.

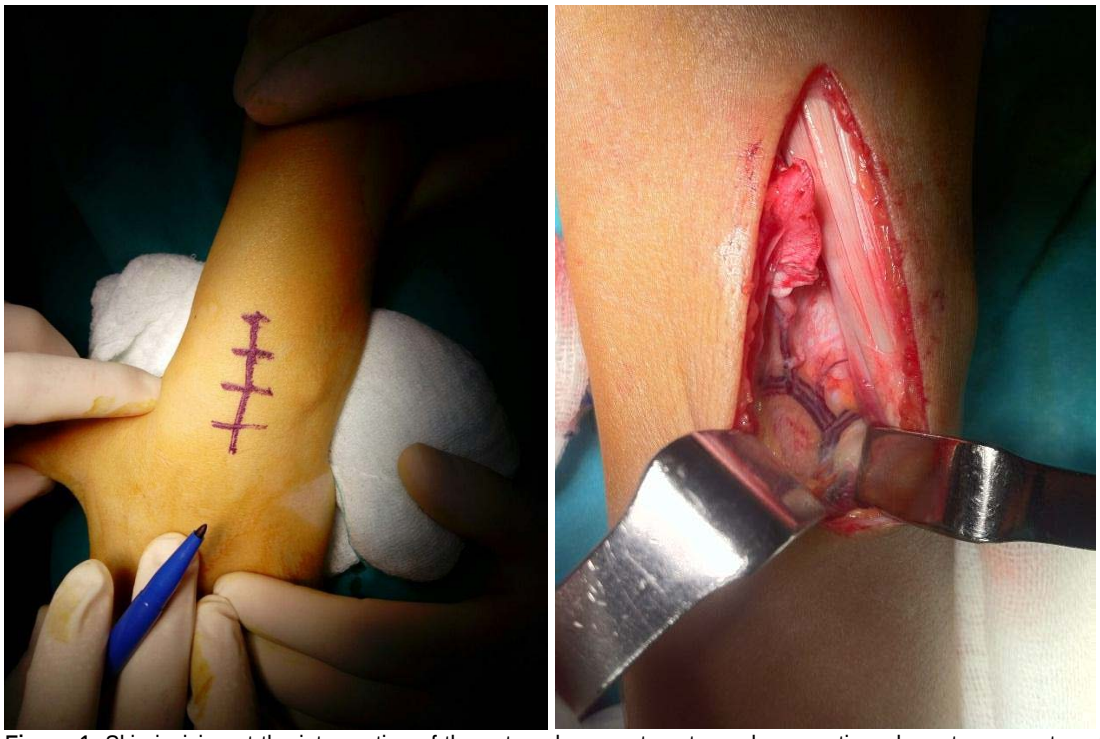

Figure 1. Skin incision at the intersection of the external compartments, and supraretinacular extracompartmental artery graft site *(Harran University, Faculty of Medicine, Orthopedics and Traumatology Department Archive)*

Figure 2. Vascular bone graft taken during surgery
(Harran University, Faculty of Medicine, Orthopedics and Traumatology Department Archive)

Bone union status, carpal height ratio, Stahl index, and ulnar variance rates were measured and recorded. In clinical examinations, preoperative and postoperative wrist extension and flexion range of motion (ROM) were measured with a digital (electronic) goniometer and recorded. The wrist grip strength of all patients was determined with a wrist dynamometer. Functional and pain states of the patients were evaluated with MMWS, Q-DASH and VAS. Revascularization status in the graft and lunate was evaluated by evaluation of postoperative MRI signal changes and osteoblastic activity in bone scintigraphy. Hyperintense appearance (especially in T2 sequence), contrast enhancement and medullary signal increase were evaluated in favor of revascularization (28-32).

*Assessment of Ulnar Variance:*The ulnar variance is the distance between the wrist bones and the ulna and its normal value is 0.9 mm(33).if the ulna and radius joint levels are equal, it is called neutral ulnar variance, if the ulna joint face is more distal, positive ulnar variance, if the ulna joint face is more proximal than the radius joint face, it is called negative ulnar variance(31).

Carpal Height Ratio: Reduction in carpal height is determined by the decrease in this value. The numerator of this fraction is defined as the distance between the proximal onset of the third metacarpal bone and the distal joint surface of the radius, while the denominatoris the longitudinal length of the third metacarpal bone. The normal range of carpal height ratio is 0.54 ± 0.03 (31,34).

Stahl Index: This value is calculated on the lateral radiograph.It is defined as the ratio of the height of the lunate to its width. Normal values are around 0.53 ± 0.03(22, 31, 35).

Evaluation of pain: The VAS is a scale that allows subjective assessment of the severity of pain according to the reports of the patients themselves. In this scale, the patient determines their pain level from 0 (no pain)to 10 (most severe pain suffered by the patient)(36).

Q-DASH: The Q-DASH is used for functional and symptomatic evaluation. The scores of the patients are calculated according to the answers they give to the questions that comprise the measurement. Maximum value is 100. Higher scores represent worse results(37).

MMWS: Patient satisfaction and clinical results were evaluated with the MMWS. In this system, a score out of 100 is calculated by evaluating pain, functional status, ROM and grip strength. In the evaluation of scores, values between 0-50 are considered'poor', 51-65 are 'acceptable', 66-80 are 'good', and 81-100 are 'excellent'(38).

Statistical analysis

Statistical analysis was performed using the SPSS (Statistical Package for Social Sciences) version 21.0 package program. The McNemar test was used for comparison of dependent categorical variables. The suitability of continuous variables to normal distribution was evaluated by the Shapiro Wilk test. The Mann Whitney U test was used for comparison of two independent groups, while the Wilcoxon Signed Ranks test was used for comparison of dependent groups. $p < 0.05$ was considered statistically significant.

Results

Seven of the cases were female (58.3%) and 5 of them were male (41.7%). Nine of the patients (75%) were between the ages of 16-30,overallmean age was 27.83 (minimum: 16, maximum: 57). Seven (58.3%) of the cases were on the right wrist, while the dominant wrist was affected in 10 (83.3%) cases. There was no known trauma history in 9 (75%) cases. After the operation, the MMWS result was good / excellent in 11 (91.7%) patients, and the Q-DASH score of these patients was between 5-20. Nine (75%) patients reported a VAS score of 2 and below (Table 1).

Table 1. Summary of Patients' Characteristics and Examined Scores

Age	27.8 (16 - 57)
Gender	
Male	5 (41.7%)
Female	7 (58.3%)
Side	
Right	7 (58.3%)
Left	5 (41.7%)
Hand dominancy	
Dominant	10 (83.3%)
Non-dominant	2 (16.7%)
History of trauma	
No	9 (75.0%)
Yes	3 (25.0%)
The Modified Mayo Wrist Score (score)	
Excellent (81-100)	9 (75.0%)
Good (66-80)	2 (16.7%)
Acceptable (51-65)	-
Poor (0-50)	1 (8.3%)
Q-DASH score	
5-10	6 (50.0%)
11-20	5 (41.7%)
41-50	1 (8.3%)
Visual Analog Scale for Pain	
0-1	6 (50.0%)
1-2	3 (25.0%)
2-3	1 (8.3%)
4-5	1 (8.3%)
5-6	1 (8.3%)

Data are given as mean (minimum - maximum) for continuous variables and as frequency (percentage) for categorical variables

In both preoperative and postoperative evaluation, negative ulnar variance was determined in 9 (75%) cases and

neutral ulnar variance in 3 (25%) cases. None of the patients had positive ulnar variance. While evaluating the Stahl index, 1 patient was excluded from the analysis because the preoperative graph could not be reached; however, there was no significant change in Stahl index values of the evaluated patients (n = 11). Preoperative flexion and extension range of motion values were found to have significantly increased at postoperative measurement ($p < 0.05$). When compared with preoperative values, it was determined thatpostoperative carpal height ratio was significantly lower, while wrist grip strength was significantly increased (Table 2).

Table 2. Physical examination and radiographic evaluations at the preoperative period and last follow-up.

	Preoperative	Final follow-up	p
Radiographic evaluation			
Ulnar variance (negative/neutral)	9/3	9/3	>0.05
Stahl Index	0.382	0.365	>0.05
Carpal height ratio	0.506	0.482	<0.05
Wrist grip strength (pound)	49.25	54.40	<0.05

Data are given as mean for continuous variables and as frequency for categorical variables

Postoperative scintigraphy was performed in 11 cases. Osteoblastic activity was detected in 10 cases. Among these 11 patients, MRI was obtained for 10 individuals. Imaging results conclusive for revascularization were present in 5 of these cases.

Discussion

Kienböck's disease is a painful conditionthat negatively affects daily activities and life satisfaction. Decompression of the lunate and accession of sufficient circulationcan facilitate recovery. In this study evaluating the postoperative clinical and radiological results of Kienböck patients treated with pedicled VBG distal to the radius, 10 of 11 cases were found to have increased osteoblastic activity and / or increased blood supply, as measured by bone scintigraphy. In addition, revascularization findings were determined in half of these cases with MRI images. Compared to preoperative characteristics, it was found that flexion and extension ROM increased, carpal height ratio decreased, and wrist grip strength increased after the operations.

One of the most important goals in the treatment of Kienböck's disease is to provide revascularization which ensures blood supply to the bone, facilitating recovery with normal morphology. Based on this target, the bone scintigraphy results of our patients revealed osteoblastic activity and / or increased blood supply in 10 of 11 patients. In addition, half of these 10 patients had an image compatible with revascularization on MRI. In the literature, studies using VBGs from many different regions report successful results. Revascularization was reported in 77% of patients in a studyperforming surgery via transverse volar carpal artery treatment(16). In a study evaluating the results of radial shortening, it was shown that 37% of patients achieved revascularization according to MRI results (17). Moran et al., in their publication of the use of 4 + 5 ECA VBG in Kienböck's disease,reported that revascularization was achieved in 71% of patients according to MRI results(23). In a critical systematic review, Tsantesand colleagues collectively reviewed 4 different studies in which the results of Kienböck patients treated using 4 + 5 ECA VBG were published. They reported that 71% revascularization was achieved in MRI or conventional X-rays when patients with Lichtman classification of stage II-III were included; however, the authors reported a considerable variation in follow-up times between studies (24).In a study by Park et al. that utilized a similar technique (4th ECA VBG)in 13 patients, positive clinical results were reported concerning ROM (35–40% increase) and grip strength (reaching 88% of the contralateral wrist, from a preoperative value of 61%) (25).In our study, although the 50% revascularization rate detected in patients with MRI seems to be lower than other studies,scintigraphy results were very positive. In addition, since revascularization criteria are not clearly stated, it is possible to suggest that there may be differences between studies in terms of evaluation ofresults.

Ensuring that joint movements are within normal limits increases patient satisfaction due to the ability to perform daily functions. In addition, reaching the desired level of ROM is an important indicator in evaluating the effectiveness of the treatment ofKienböck's disease. In our study, it was found that flexion and extension ROM increased significantly in postoperative follow-up compared to preoperative values. Park et al. also demonstrated satisfactory function with the same method (25). By examining different studies using a similar surgical method, it was shown that there was a statistically significant improvement compared to the preoperative period (66% vs. 77% of normal ROM) (24).On the other hand, Gillis et al. also showed that ROM values of Kienböck's patients changed positively after the utilization of revascularization procedures(39).As a result, it is evident that ROM values are generally positively affected in different surgical procedures. However, since the number of studies comparing ROM between different surgical methods in Kienböck's disease treatment is not sufficient, it is not possible to interpret which method is more advantageous. However, as a result of our study, we can say that the procedure we performed has rather satisfactory effects in terms of ROM. By examining different surgical methods together or by performing systematic reviews, differences between procedures can be determined and procedures can be assessed in terms of their advantages and disadvantages.

The primary therapeutic targets with revascularization surgery are to prevent collapse, obtain healing with graft and blood support, and to roughly create normal morphological features. In our study, it was determined that the postoperative carpal height ratio –which is one of the parameters examined for this purpose– decreased compared to preoperative values. Although this decrease was statistically significant, we think that the change may not be direct indicator of outcome, especially considering patient satisfaction and other parameters that indicatedrevascularization of the lunate. We also found that there was a significant change in the postoperative Stahl Index measurements, and we believe this was due to the restoration of normal anatomy secondary to revascularization. Contrary to our study, Park et al., as a result of their study with 4th ECA pedicled VBG, reported that there was no statistically significant difference in carpal height ratio in their patients;whereas, similar to our results, VAS, grip strengthand ROM values had demonstrated significant improvements in post-operative follow-up(25).Similarly, Moran et al. reported minimal (insignificant) change in carpal height ratio and Stahl Index values in the postoperative follow-up of Kienböck patients treated with 4 + 5 ECA VBG. Based on this finding, they suggested that lunate collapsecan be prevented by lunate expansion and decompression (23).

One of the most important indicators of functional recovery in Kienböck's disease is the ability to utilize the wrist with sufficient strength and without pain. The present results show that wrist grip strength, as measured with a wrist dynamometer, was increased significantly in postoperative evalautions when compared to preoperative measurements. Similarly, in other studies, it was shown that grip strength increased significantly in post-operative follow-up (54% vs. 88% of normal grip strength) (24).Among these studies, a significant increase in grip strength was shown in studies using the same procedure as our study (61% vs. 88% of normal strength)(25).By providing revascularization, the pathological process causing pain in the joint disappears; thusdecreasing VAS score in the majority of patients and indirectly causing positive developments in ROM and grip strength h. In accordance with this situation, it has been shown in other studies that the decrease in VAS score and the increase in ROM and grip strength values are often observed in unison(18, 23, 25). As a matter of fact, it was observed that all but one of the patients had excellent or good results according to the MMWS which is an overall measure that assesses these parameters. Reporting a similar result, Aydemirand colleagues reported that patients' postoperative Mayo Wrist Scores werepositively influenced in their report of results with a surgical technique that was similar to the one used in our study(26).Thus, it is evident that the procedure utilized for the treatment of Kienböck's disease in this study was very effective in functional recovery.

Our study has several limitations. The low number of patients and the short follow-up period are the main limitations of our study. Therefore, the generalizability of the results should be evaluated in this respect. Since the effectiveness of different treatments were not examined, these results should not be interpreted as a direct advocacy of the specific treatment applied, rather our findings show that this approach is a reliable therapeutic option. It is also important to note that the MMWS, Q-DASH and VAS scores of the cases were not recorded before the operation. For this reason, we cannot report comparative evaluations regarding these scores. Although this is an important limitation, particularly for VAS scores which are subjective by nature, it must be noted that the MMWS and Q-DASH results indicate very good outcomes even without preoperative results. Additionally, due to sociodemographic and sociocultural factors, imaging methods such as scintigraphy and MRI could not be obtained at the planned 12-month time point after the procedures. However, this was unavoidable due to the fact that the study was performed in a region with high frequency of seasonal workers (in the spring and summer months); thus, imaging studies were obtained earlier or later than planned. In addition, this situation made it difficult to perform physical exams and scoring in the same time interval during postoperative follow-up.

In conclusion, the use of the pedicled VBG for the treatment of Kienböck's disease is very successful in providing revascularization and restoring functionality. Revascularization was detected in scintigraphy in all but one patient, whereas the MRI images from these 10 patients were conclusive for revascularization in five patients. Treatment-specific results can be explored in more detail with the inclusionof more patients and with thecomparion of different surgical procedures. However, such studies are difficult due to the rarity of the disease. Even so, such efforts will be helpful in the selection of appropriate options in the treatment of Kienböck's disease.

Ethical Approval: Ethics committee approval was obtained from the Ethical Committee of the Medical Faculty at Harran University. (Decision number 15/07/05).

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