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Original Research

Comparison of Distal Radius Autograft Technique with Iliac Crest Autograft Technique in Solitary Finger Enchondromas

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Abstract

Objectives: The purpose of the study was to compare clinical and radiological outcomes of autografts obtained from the iliac crest (IC) and distal radius (DR) and to evaluate their superiority for surgical treatment of solitary finger enchondromas.

Methods: Twenty-five patients for whom curettage and autografting were carried out for finger enchondroma were retrospectively analyzed. DR autograft was used in eight patients and IC autograft was used in 17 patients. Data on pre-operative total active motion (TAM), disabilities of the arm, shoulder, and hand (DASH) score, and pain visual analog scale (VAS) scores of the involved finger, duration of surgery, amount of bleeding during the operation, length of hospital stay, presence of complications related to anesthesia, and post-operative donor site morbidity were obtained. Pre-operative and post-operative 12th month radiographies were evaluated for pre-operative tumor volume, post-operative remnant volume, and Tordai radiologic evaluation grade.

Results: No statistically significant difference could be identified between post-operative TAM (p=0.154), DASH (p=0.458), pain VAS scores (p=0.571), remnant volume (p=0.496), Tordai radiologic evaluation grade (p=0.522), duration of surgery (p=0.288), and amount of bleeding (p=0.114) between DR and IC groups. However, mean hospital stay duration was shorter for the DR group (p=0.0001). Recurrence was observed in one patient in the DR group and three patients in the IC group (p=0.996).

Conclusion: The clinical and radiological outcomes of grafting from the DR and IC were similar in the treatment of hand enchondromas. However, grafting from the DR may result in shorter hospital stay compared to IC grafting.

Keywords: Bone grafting, bone neoplasm, Local anesthesia, Pathological fracture

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While solitary enchondromas are hamartomas originating from the hyaline cartilage tissue in the bone, multiple enchondromas are a type of bone dysplasia.[1] Solitary enchondromas are commonly observed in the long bones of the hand and are the most frequently encountered primary bone tumors of the hand. They are often located on the ulnar fingers and the proximal phalanx.[2] Although solitary enchondromas are often silent, the first finding may be fractures. The main treatment in symptomatic patients is surgery.[3] The purpose of treatment is to prevent fracture and deformity and to establish histopathological diagnosis.

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The main surgical method in enchondroma is open or endoscopic curettage.[4] Treatment of the cavity formed after curettage can vary. In addition to curettage, chemical cauterization can be applied to the cavity with phenol, alcohol, liquid nitrogen, and CO_2 laser; additionally, physical cauterization can be performed with a high-speed burr.[5-8] Studies suggest that the cavity can either be filled with bone graft, bone substitutes, and polymethylmethacrylate (PMMA) or can be left empty.[9-13] No obvious superiority of these techniques over the other has been reported.[8,14-16]

Bone autografts are at the forefront of treatment of bone defects because they stimulate regeneration of bone tissue and provide mechanical support.[17] Although the iliac crest (IC) is often preferred as an autograft source, proximal and distal tibia, trochanter major and distal radius (DR) are good alternatives.[18] The biggest disadvantage of autografts is the development of donor site morbidity.[18] Cortical or corticocancellous bone grafts up to 3 cc can be harvested from the DR.[19] Although this amount is well below the amount obtained from the IC, it is often sufficient in hand and wrist surgeries. DR grafts are preferred in hand surgery because they keep the surgical area within the relevant extremity and eliminate the need for general anesthesia.[20] On the other hand, DR bone grafts are structurally weaker than IC grafts and have a slower turnover.[21]

The iliac bone stands out as the source of autograft in hand enchondromas. Nonetheless, it is not known which of these two graft sources, DR or IC with distinct characteristics, is superior in the treatment of enchondroma.[22] DR grafts keep the operation area more limited, making the anesthesia method more selective, and they reduce the affected extremity to one, all of which are important advantages. However, the structural weakness of DR grafts compared to IC grafts may prove to be a disadvantage during recovery. Therefore, in our study, we aimed to compare the clinical and radiological outcomes of IC and DR autografts in the treatment of solitary enchondromas in the fingers.

Methods

The study was conducted with the approval of the local ethical committee (07/10/2021.77.542) and in accordance with the Declaration of Helsinki. Patients who were operated for enchondroma in the fingers between January 2013 and January 2020 at our clinic were retrospectively examined. The patients were included in the study according to the following criteria: (1) Location of enchondroma in the fingers of the hand, (2) diagnosis of enchondroma by histopathological examination, (3) age older than 18 years, and (4) follow-up for at least 12 months. The exclusion criteria were as follows: (1) Presence of fixation with implant, (2) presence of revision surgery, and (3) presence of arthrosis in the adjacent joint.

Thirty-two patients who met the inclusion criteria were selected. Data from 25 of these patients could be accessed. DR was used as bone graft donor site in eight patients while IC was used in 17 patients. In the DR group, the number of female patients was four and the number of male patients was four; in the IC group, the number of female patients was 11 and the number of male patients was six. The mean age in the DR group was 36 years (range 22-54 years), while the mean age in the IC group was 33 years (range 22-52 years). The patients were diagnosed with lesions after admission to the hospital. None of the patients had complaints of pain; eight had fractures, and five had swelling, and three cases were discovered incidentally.

Evaluation Criteria

Data on effected side, finger, phalanx, pre-operative total active range of motion (TAM) of the involved finger, disabilities of the arm, shoulder, and hand (DASH) score, and pain visual analog scale (VAS) scores, duration of the operation, amount of bleeding during the operation, length of hospital stay, presence of complications related to anesthesia, and post-operative donor site morbidity were obtained from patient files. The amount of bleeding was determined according to the number of sponges used and the extent of wetting of these sponges. Sponges that were not fully wet were estimated to correspond to 5 ml of blood while fully wet sponges corresponded to 10 ml of bleeding. The patients were recalled, and the TAM, DASH, and VAS scores were re-evaluated, along with reassessment of donor site morbidity. Complications and recurrences in the patients were evaluated. In addition, localization of tumor (eccentric/central/associated), form of the tumor (expanding/nonexpanding), and type of tumor (monocentric/polycentric and giant) were classified according to Hasselgren classification[13] (Fig. 1). The lesion volume was calculated on the pre- and post-operative anteroposterior (AP) and lateral radiographs (cylindrical lesion: Width/2xdepth/2xheightxπ; spherical lesion: Width/2xdepth/2xheightx4/3π).[23] In the post-operative AP and lateral follow-up radiographs of the patients, the presence of graft incorporation as well as remnant lesion volume (if any) was measured by the equation above. Graft incorporation was evaluated and graded according to Tordai staging.[24]

Surgical Technique

Hand surgery operations are performed by two surgical teams in our tertiary hand surgery center. With the similar indications, the first team prefers IC bone grafting for hand bone tumors while the second team prefers DR bone graft-

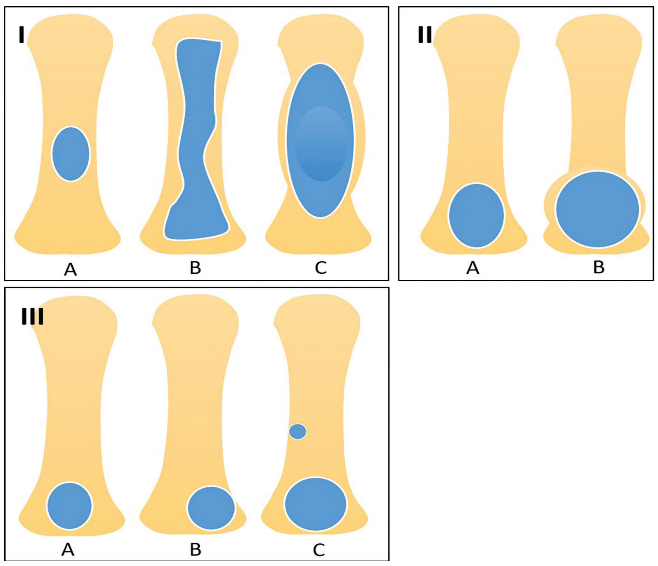

Figure 1. Hasselgren classification. I: Type of tumor: (a) Monocentric, (b) polycentric, and (c) giant. II: Form of tumor: (a) Non-expanding and (b) expanding. III: Localization of tumor: (a) Central, (b) eccentric, and (c) associated.

ing. Patients were summoned blindly by clinical secretary and added to surgery lists of each surgical team.

Among the patients who underwent DR grafting, four were operated with infraclavicular brachial plexus block (ICBPB), two with regional intravenous anesthesia, and two with wide awake anesthesia no tourniquet (WALANT). Among the 14 patients that underwent IC grafting, 11 were subjected to ICBPB and deep sedation while general anesthesia was used in three patients. A tourniquet was applied to all patients, except for those who received WALANT.

For the finger under surgery, incisions were made through the dorsoradial or dorsoulnar side at the level of the proximal phalanx, through the central side at the level of the mid-phalanx and the ulnar or radial side at the level of the distal phalanx. The enchondroma content was evacuated following the opening of the bone window with the help of C-arm scopy. The cyst walls were cleaned with a curette and then with a high-speed burr. After that, the amount of bone graft needed was determined.

For DR graft removal, the radius was entered through a transverse incision made from the dorsal over the radial styloid. The radius was reached by going deeper between the first and second extensor compartments, preserving the superficial sensory branch of the radial nerve and the veins. The bone window was opened, and the bone graft was taken (Fig. 2). To obtain the IC graft, a longitudinal incision was made over the IC from 3 cm posterior to the anterior superior iliac spine. Electrocautery was used to cut deeper, with attention paid to preserving the lateral femoral cutaneous nerve. A bone window was opened in the iliac bone to take the bone graft; the latter was then placed in the bone cavity in the phalanx. An under-elbow splint was applied for a week to the patients in the DR group. Finger splints were used in the IC group.

Statistical Evaluation

Statistical analyses were carried out with NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) package program. In addition to descriptive statistical methods (mean, standard deviation, median, and interquartile), the distribution of variables was evaluated with

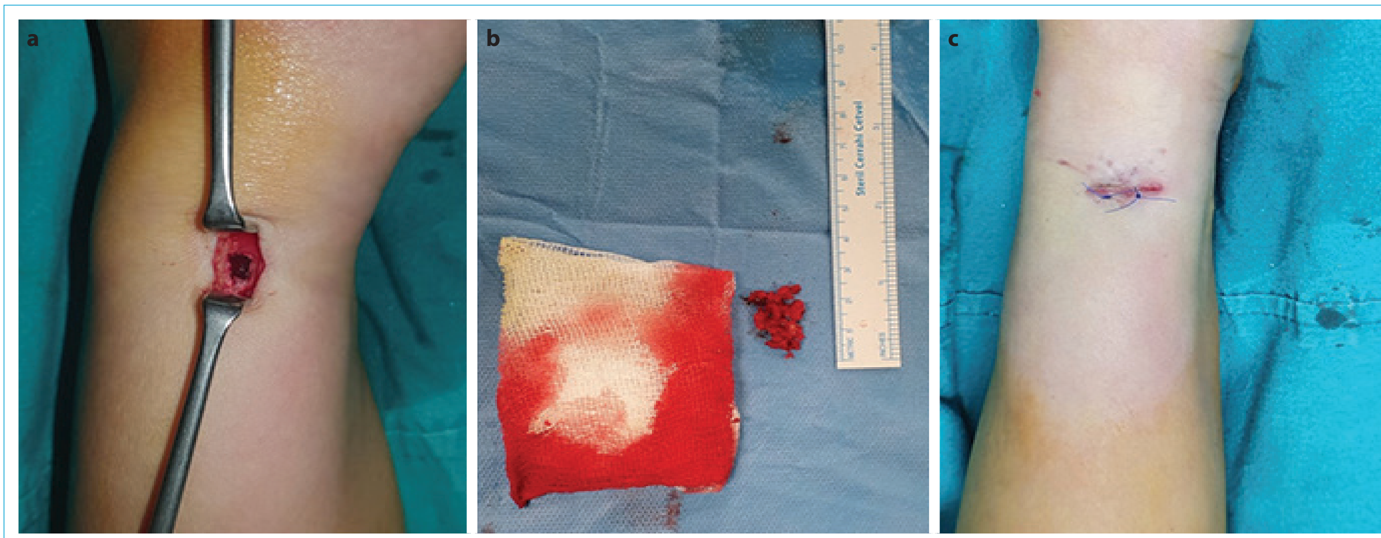

Figure 2. Surgical photographs of a patient operated with distal radius graft under WALANT surgery. **(a)** A transverse incision was made from the dorsal over the radial styloid, the radius was reached by going deeper between the first and second extensor compartments, and the bone window was opened. **(b)** Amount of bone graft obtained and amount of bleeding. **(c)** Skin closure.

Table 1. Donor sites of bone grafts, Hasselgren classification, location of enchondroma, pre-operative enchondroma volume, and post-operative remnant volume

Patient, graft donor	Hasselgren classification	Location of enchondroma	Pre-operative enchondroma volume (cc)	Post-operative remnant volume (cc)
1/DR	Monocentric/non-expanding/central	Right/second finger/mid-phalanx/proximal metaphysis	0.635	0.11
2/DR	Polycentric/expanding/central	Left/third finger/distal phalanx/proximal metaphysis	0.432	0.74
3/DR	Monocentric/non-expanding/central	Right/third finger/mid-phalanx/proximal metaphysis	0.349	0
4/DR	Monocentric/non-expanding/central	Left/second finger/proximal phalanx/distal metaphysis	0.859	0
5/DR	Monocentric/expanding/central	Right/thumb/distal phalanx /proximal metaphysis	1.978	0
6/DR	Monocentric/expanding/central	Left/fifth finger/proximal phalanx/proximal metaphysis	1.016	0
7/DR	Monocentric/expanding/eccentric	Right/third finger/mid-phalanx/diaphysis	0.247	0
8/DR	Monocentric/expanding/central	Right/second finger/distal phalanx/distal metaphysis	0.455	0
9/IC	Polycentric/expanding/eccentric	Right/forth finger/proximal phalanx/proximal metaphysis	1.23	1.04
10/IC	Monocentric/expanding/eccentric	Right/third finger/proximal phalanx/proximal metaphysis	2.567	1.787
11/IC	Polycentric/expanding/central	Left/third finger/proximal phalanx/proximal metaphysis	1.34	1.257
12/IC	Monocentric/non-expanding/central	Right/third finger/proximal phalanx/proximal metaphysis	1.261	0.141
13/IC	Monocentric/non-expanding/central	Left/second finger/proximal phalanx/proximal metaphysis	0.899	0
14/IC	Polycentric/expanding/eccentric	Right/forth finger/mid-phalanx/proximal metaphysis	0.246	0
15/IC	Monocentric/expanding/central	Right/third finger/distal phalanx/ proximal metaphysis	0.39	0
16/IC	Monocentric/expanding/eccentric	Left/third finger/mid-phalanx/proximal metaphysis	1.378	0
17/IC	Polycentric/expanding /eccentric	Right/second finger/proximal phalanx/distal metaphysis	2.072	0
18/IC	Monocentric/expanding/eccentric	Left/forth finger/proximal phalanx/proximal metaphysis	1.526	0
19/IC	Monocentric/non-expanding/central	Right/forth finger/mid-phalanx/distal metaphysis	0.517	0
20/IC	Polycentric/expanding/central	Left/third finger/mid-phalanx/diaphysis	0.998	0
21/IC	Monocentric/expanding/central	Right/thumb/distal phalanx/proximal metaphysis	0.896	0
22/IC	Monocentric/expanding/central	Left/second finger/proximal phalanx/proximal metaphysis	1.487	0
23/IC	Polycentric/non-expanding/central	Right/forth finger/proximal phalanx/diaphysis	0.618	0
24/IC	Polycentric/non-expanding/eccentric	Right/forth finger/mid-phalanx/diaphysis	0.415	0
25/IC	Monocentric/expanding/central	Left/fifth finger/proximal phalanx/distal metaphysis	1.647	0

DR: Distal radius; IC: Iliac crest

the Shapiro-Wilk normality test; independent sample t-test was used for comparison of normally distributed variables in paired groups; Wilcoxon test was applied for comparison of non-normally distributed variables; Mann-Whitney U-test was used for the comparison of binary groups, and Fisher's exact test and the Chi-square test were used for the comparison of qualitative data. The results were analyzed at the significance level of $p<0.05$.

Results

Tordai and Hasselgren classifications, involved side, finger, phalanx, and localization at phalanx, pre-operative lesion volumes, and post-operative remnant lesion volumes of the patients, are given in Table 1. The localization of tumor - eccentric or centric - was similarly distributed in both groups p=0.205). The mean bone cyst volume was 0.75 cc (±0.56) in the DR group and 1.15 cc (±0.62) in the IC group; this difference did not reach statistical significance (p=0.137). At the post-operative follow-up, the mean remnant lesion volume in the DR group was 0.11 cc (±0.26) and 0.25 cc (±0.55) in the IC group (p=0.496). Tordai's radiological evaluation criteria were also statistically similar between the groups (p=0.522) (Table 2, Figs. 3, 4).

The mean amount of bleeding during surgery was 37.5 ml (±11.02) in the DR group and 43.53 ml (±13.67) in the IC group (p=0.288). The duration of surgery was 63.75 min (±27.87) in the DR group and 81.76 min (±25.55) in the IC group (p=0.114). None of these comparisons reached statistical significance. The mean hospital stay was 13.25 h (±6.58) in the DR group and 38.82 h (±9.9) in the IC group; this difference was significantly shorter in the DR group (p=0.0001) (Table 2).

One patient in the DR group exhibited loss of sensation in the first web due to injury to the radial nerve sensory branch. This complaint was completely resolved at the follow-up examination. No complications were observed

Table 2. Mean values and statistical evaluation of age, gender, pre-operative and post-operative TAM (total active motion), localization of tumor, pre-operative tumor volume and post-operative remnant volume, amount of bleeding, duration of surgery, duration of hospital stay, and Tordai radiographic evaluation grade

Group/ Count (n) and Percentage (%)	Group DR, n=8		Group IC, n=17		p
	n	%	n	%	
Age	35.75±9.81		33.41±9.85		0.585*
Gender					
Male	4	50.00	6	35.29	0.484+
Female	4	50.00	11	64.71	
Pre-operative TAM	243.13±7.99		220.59±27.55		0.035*
Post-operative TAM	253.75±12.7		247.94±7.51		0.154*
Pre-operative volume of enchondroma	0.75±0.56		1.15±0.62		0.137*
Post-operative remnant volume	0.11±0.26		0.25±0.55		0.496‡
Amount of bleeding	37.5±11.02		43.53±13.67		0.288*
Duration of surgery	63.75±27.87		81.76±24.55		0.114*
Duration of hospital stay	13.25±6.58		32.82±9.9		0.0001*
Tordai radiographical evaluation grade					
Grade 1	4	50.00	10	58.82	0.522+
Grade 2	3	37.50	3	17.65	
Grade 3	1	12.50	4	23.53	
Recurrence	1	12.5	3	17.65	0.996¡

*: Independent t-test; +: Chi-square test; ‡: Mann-Whitney U-test; ¡: Fisher's exact test. DR: Distal radius; IC: Iliac crest; TAM: Total active range of motion

in the iliac bone group. Recurrence was observed in one patient in the DR group and three patients in the IC group (p=0.996).

The pre-operative finger TAM in the IC group was significantly more restricted compared to the DR group (p=0.035); however, this difference between the two groups was lost at the 6th month after the operation (p=0.154). While the mean pre-operative DASH and VAS scores were higher in the IC group (p=0.008 and p=0.025, respectively), the difference between the two scores was lost at the 6th month after the operation (p=0.458 and p=0.571, respectively) (Table 3).

Discussion

We observed in the present study that bone grafting of finger enchondromas with curettage produced similar clinical and radiological results irrespective of use of DR or IC as the source of graft. In addition, DR grafting was found to shorten the length of hospital stay.

Figure 3. Patient operated with distal radius autograft technique. **(a)** Pre-operative anteroposterior view. **(b)** Pre-operative lateral view. **(c)** Post-operative 12th month anteroposterior view. **(d)** Post-operative 12th month lateral view.

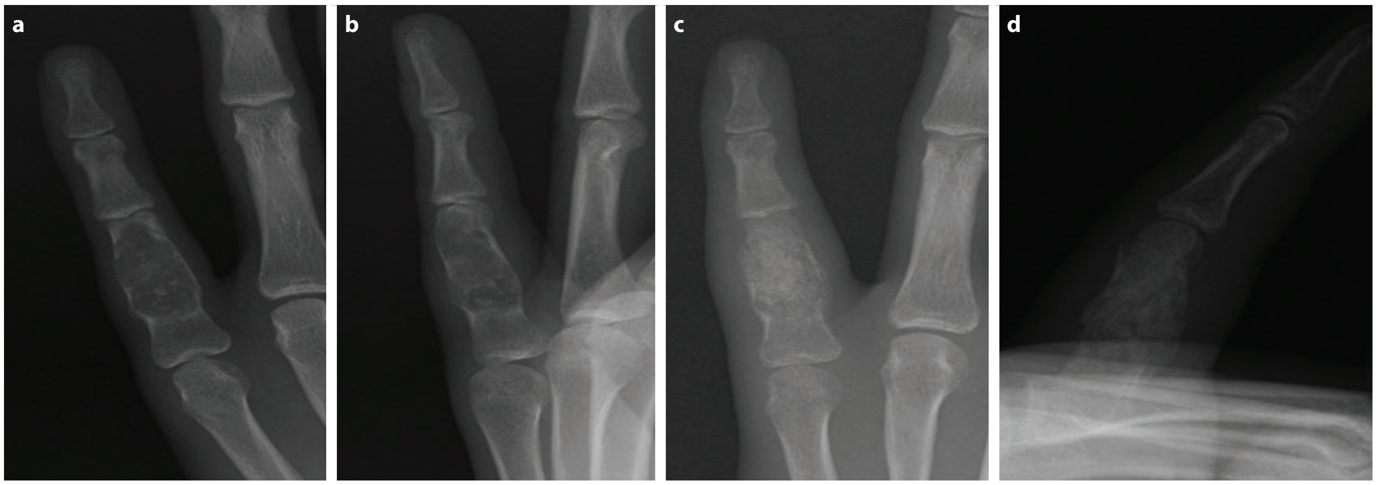

Figure 4. Patient operated with iliac crest autograft technique. **(a)** Pre-operative anteroposterior view. **(b)** Pre-operative lateral view. **(c)** Post-operative 12th month anteroposterior view. **(d)** Post-operative 12th month lateral view.

About 35% of solitary enchondromas are located in the hand and constitute 90% of all hand bone tumors. They frequently develop in the 4th decade of life.[25] Corroborating this, the mean age of the cohort in the present study was 34 years (±9.7). A meta-analysis by Gaulke et al.[2] reported that enchondromas were located more frequently in the proximal phalanx of the fingers followed by the mid-phalanx and the distal phalanx. In the same study, it was stated that the 5th finger was the most frequently affected one. Similarly, Sassoon et al.[3] observed that in a group of 80 patients with 102 enchondromas, the most commonly affected regions were the proximal phalanx and the 5th finger. In our study, it was also observed that involvement of the proximal phalanx was the most common (13/25). However, involvement of the third finger was more frequent (9/25).

There is no standard protocol for the treatment of enchondromas located in the hand. Enchondromas are defined as slowly progressive active lesions and malignant transformation is rare. For this reason, regular radiological follow-up is suggested in cases with incidentally detected and asymptomatic enchondroma.[26] Tang et al.[26] reported that surgery was required for the treatment of polycentric hand enchondromas or those with centric and obvious cortical thinning or giant enchondromas. Major differences in outcomes of surgical treatment of enchondromas can be observed when the cavity formed after curettage is filled. Haselgren et al.[13] left the cavity empty after curettage in 28 patients and observed adequate ossification in all patients within 6 months. On the other hand, there are publications stating that leaving the cavity empty may lead to fracture.[27] Autologous or allografts, PMMA, and other synthetic materials have been used to fill the cavity.[10-12,14,15] Yercan et al.[14] reported no differences in the outcomes of patients undergoing allografts and iliac bone autografts. A study comparing iliac bone autografts and allografts for the treatment of enchondroma indicated that despite similar results in recipient site healing, donor site morbidity posed a problem for the autograft donor site. We prefer the use of autograft in our clinic because of its superior osteoinductive, osteoconductive, and osteogenic properties. In addition, reports of delayed union and infection in patients who underwent allograft[28] are the other reasons for our choice of autograft.

Although the iliac bone is the main donor source of autograft in the treatment of hand enchondromas, treatments with autografts from the DR are also available in the literature.[14-16,22] In a histomorphological study, Schnitzer et al.[21] compared DR and IC samples. These authors observed that DR had a higher fatty marrow content, was structurally weaker, and had lower bone turnover and recommended the use of IC grafts in cases where rapid bone support was required. The use of DR bone grafts was recommended for filling small cavities that did not need structural support.

Either technique has its own complications. The use of IC as the source of bone graft is associated with serious complications such as deep hematoma, incisional hernia, urethral injuries, gait disturbances and pelvis fractures with a probability of 5-6%.[29] Patel et al.[30] reported that the complication rate for DR was 1.7%, and these included de Quervain's tenosynovitis, DR fracture, and paresthesia in the radial nerve sensory branch. In the present study, we observed that both DR and IC grafts showed a radiologically similar healing process; there was no difference in recurrence rates either. On the other hand, temporary paresis was observed in the sensory branch of the radial nerve in one patient in the DR group. The main advantages of DR grafting were the requirement of regional anesthesia and restriction of the field of operation in one region, which contributed to a faster discharge of the patients. Moreover, the anesthesia was limited further in the present study by performing DR grafting in two patients with WALANT, similar to the study by Xing et al.[31,32]

The main limitations of the study are its retrospective design and inclusion of a low number of patients. However, considering that the study included patients with an uncommon tumor located in the finger, the number of recruited patients may be considered to be sufficient. Other studies in the literature also consisted of similar sample sizes. The final limitation is the lack of inclusion of data on patient satisfaction. On the other hand, we observed that patients with DR grafting showed high satisfaction due to early discharge from hospital and restraining the operation area only on the relevant limb.

Conclusion

The clinical and radiological outcomes of grafting from the DR and IC were similar in the treatment of hand enchondromas. However, DR grafting restricted the surgical field to one limb. Patients with DR grafting had a shorter the hospital stay compared to patients with IC grafting; however, the amount of bleeding and the duration of surgery were not different between the two methods.

Disclosures

Ethics Committee Approval: The study was apporeved by the Metin Sabancı Baltalimanı Bone Diseases Research and Training Hospital Local Ethics Committee (Date: 07/10/2021 No: 77.542).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Concept – O.O., I.F.A.; Design – O.O., I.F.A., A.S., M.B., M.O.; Supervision – O.O., A.S., M.B; Materials – O.O., I.F.A., A.S., M.B., M.O.; Data collection &/or processing – I.F.A., A.O.; Analysis and/or interpretation – O.O., I.F.A., M.O., A.O.; Literature search – O.O., I.F.A., A.S., M.B.; Writing – O.O., I.F.A.; Critical review – A.S., M.B.

References

1. Inwards CY, Carter JM, Oliveira AM. Tumors of the osteoarticular system. In: Fletcher CDM, editor. Diagnostic Histopathology Of Tumors. 5th ed. Philadelphia: Elsevier; 2021. p. 2002–66.
2. Gaulke R. The distribution of solitary enchondromata at the hand. J Hand Surg Br 2002;27:444–5.
3. Sassoon AA, Fitz-Gibbon PD, Harmsen WS, Moran SL. Enchondromas of the hand: factors affecting recurrence, healing, motion, and malignant transformation. J Hand Surg Am 2012;37:1229–34.
4. Sekiya I, Matsui N, Otsuka T, Kobayashi M, Tsuchiya D. The treatment of enchondromas in the hand by endoscopic curettage without bone grafting. J Hand Surg Br 1997;22:230–4.
5. Quint U, Müller RT, Müller G. Characteristics of phenol. Instillation in intralesional tumor excision of chondroblastoma, osteoclastoma and enchondroma. Arch Orthop Trauma Surg 1998;117:43–6.
6. Mohler DG, Chiu R, McCall DA, Avedian RS. Curettage and cryosurgery for low-grade cartilage tumors is associated with low recurrence and high function. Clin Orthop Relat Res 2010;468:2765–73.
7. Giles DW, Miller SJ, Rayan GM. Adjunctive treatment of enchondromas with CO2 laser. Lasers Surg Med 1999;24:187–93.
8. Cha SM, Shin HD, Kim KC, Park IY. Extensive curettage using a high-speed burr versus dehydrated alcohol instillation for the treatment of enchondroma of the hand. J Hand Surg Eur Vol 2015;40:384–91.
9. Bauer RD, Lewis MM, Posner MA. Treatment of enchondromas of the hand with allograft bone. J Hand Surg Am 1988;13:908–16.
10. Rajeh MA, Diaz JJ, Facca S, Matheron AS, Gouzou S, Liverneaux P. Treatment of hand enchondroma with injectable calcium phosphate cement: a series of eight cases. Eur J Orthop Surg Traumatol 2017;27:251–4.
11. Liodaki E, Kraemer R, Mailaender P, Stang F. The use of bone graft substitute in hand surgery: a prospective observational study. Medicine (Baltimore) 2016;95:e3631.
12. Kim JK, Kim NK. Curettage and calcium phosphate bone cement injection for the treatment of enchondroma of the finger. Hand Surg 2012;17:65–70.
13. Hasselgren G, Forssblad P, Törnvall A. Bone grafting unnecessary in the treatment of enchondromas in the hand. J Hand Surg Am 1991;16:139–42.
14. Yercan H, Ozalp T, Coşkunol E, Ozdemir O. Long-term results of autograft and allograft applications in hand enchondromas. Acta Orthop Traumatol Turc 2004;38:337–42.
15. Hung YW, Ko WS, Liu WH, Chow CS, Kwok YY, Wong CW, et al. Local review of treatment of hand enchondroma (artificial bone substitute versus autologous bone graft) in a tertiary referral centre: 13 years' experience. Hong Kong Med J 2015;21:217–23.
16. Schaller P, Baer W. Operative treatment of enchondromas of the hand: is cancellous bone grafting necessary? Scand J Plast Reconstr Surg Hand Surg 2009;43:279–85.
17. Lubahn JD, Bachoura A. Enchondroma of the hand: evaluation and management. J Am Acad Orthop Surg 2016;24:625–33.
18. Myeroff C, Archdeacon M. Autogenous bone graft: donor sites and techniques. J Bone Joint Surg Am 2011;93:2227–36.
19. Bruno RJ, Cohen MS, Berzins A, Sumner DR. Bone graft harvesting from the distal radius, olecranon, and iliac crest: a quantitative analysis. J Hand Surg Am 2001;26:135–41.
20. Mirly HL, Manske PR, Szerzinski JM. Distal anterior radius bone graft in surgery of the hand and wrist. J Hand Surg Am 1995;20:623–7.
21. Schnitzler CM, Biddulph SL, Mesquita JM, Gear KA. Bone structure and turnover in the distal radius and iliac crest: a histomorphometric study. J Bone Miner Res 1996;11:1761–8.

22. Çapkin S, Cavit A, Yilmaz K, Kaleli T. Surgical treatment of solitary enchondromas of the hand. Cureus 2020;12:e7497.
23. Hirn M, de Silva U, Sidharthan S, Grimer RJ, Abudu A, Tillman RM, et al. Bone defects following curettage do not necessarily need augmentation. Acta Orthop 2009;80:4–8.
24. Tordai P, Hoglund M, Lugnegård H. Is the treatment of enchondroma in the hand by simple curettage a rewarding method? J Hand Surg Br 1990;15:331–4.
25. Athanasian EA. Bone and soft tissue tumors. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, Cohen MS, editors. Green's Operative Hand Surgery. 7th Edition. Elsevier, Philadelphia. 2017. p. 1987–2035.
26. Tang C, Chan M, Fok M, Fung B. Current management of hand enchondroma: a review. Hand Surg 2015;20:191–5.
27. Yasuda M, Masada K, Takeuchi E. Treatment of enchondroma of the hand with injectable calcium phosphate bone cement. J Hand Surg Am 2006;31:98–102.
28. Boyce T, Edwards J, Scarborough N. Allograft bone. The influence of processing on safety and performance. Orthop Clin North Am 1999;30:571–81.
29. Arrington ED, Smith WJ, Chambers HG, Bucknell AL, Davino NA. Complications of iliac crest bone graft harvesting. Clin Orthop Relat Res 1996;300–9.
30. Patel JC, Watson K, Joseph E, Garcia J, Wollstein R. Long-term complications of distal radius bone grafts. J Hand Surg Am 2003;28:784–8.
31. Xing SG, Mao T. Surgical excision of enchondromas and osteochondromas in the hand under local anaesthesia without tourniquet. J Hand Surg Eur Vol 2019;44:745–7.
32. Öztürk İA, Öztürk K, Orman O, Baydar M, Aykut S, Köse A. Comparison of the cost and efficacy of axillary anesthesia and wide-awake anesthesia in finger surgeries. Sisli Etfal Hastan Tip Bul 2018;52:119–23.