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Early Single-Stage Curettage and Autogenous Bone Grafting for Enchondroma in the Hand with Minimally Displaced Pathologic Fracture

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Background: Enchondroma is a common benign bone tumor in the hand, often leading to delayed diagnosis due to its asymptomatic nature. The surgical treatment strategy for enchondroma, particularly in pathologic fractures, remains unclear. This study aimed to evaluate the outcomes of treatment for non- or minimally displaced pathologic fractures in enchondroma using autogenous bone grafts alone, without metal fixation.

Methods: A retrospective analysis was conducted on 34 patients who underwent surgery for enchondroma and pathologic fractures. Clinical and radiographic outcomes were assessed, including pain scores, range of motion (ROM), Disabilities of the Arm, Shoulder, and Hand (DASH) score, grip strength, fracture union time, and complications.

Results: All patients reported pain at the fracture site preoperatively. The preoperative pain visual analog scale (VAS) score was 4.5. Postoperatively, the pain VAS score improved significantly to 2.3. The postoperative average total ROM was 253.8°. The average DASH score was 5.1, and grip strength was 97.8% compared to the unaffected side. Bony union was achieved in all cases with an average union time of 10.9 weeks. No complications were observed except for 1 suspected recurrence.

Conclusions: Early single-stage surgical treatment with curettage and autogenous bone grafts without fixation yielded satisfactory results for non- or minimally displaced pathologic fractures in enchondroma. This non-fixative technique offers a viable option with reduced treatment duration and implant-related complications.

Keywords: *Enchondroma, Pathologic fracture, Fixation, Surgical outcomes, Bone tumor*

Enchondroma is a benign bone tumor that exhibits cartilaginous changes.[1,2] It is the most common bone tumor occurring in the hand.[3] As it typically demonstrates asymptomatic growth, the diagnosis is often delayed.[1,2] Most patients only become aware of the tumor's presence after seeking medical attention for a pathologic fracture resulting from trivial activities or low-energy injuries.[2,4] The indications for surgical treatment of enchondroma have not been definitively established. However, it is widely accepted that surgical intervention is necessary when pathologic fractures occur.[1,2,4,5] Traditionally, delayed treatment was considered the standard approach, postponing definitive surgery until after the consolidation of the pathologic fracture.[6,7] However, it has been pointed out that the nature of pathologic fractures itself requires a significantly long time for bone healing,[8] and the prolonged immobilization period has drawbacks such as secondary stiffness and pain.[9]

In the case of enchondroma, autografting of iliac bone is widely practiced to fill the dead space after curettage and promote bone healing.[1,4,5] For displaced fractures, methods involving bone grafts combined with fixation using K-wires or mini plates have been reported.[4,10] Recent studies have shown promising results with surgical

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techniques that combine early one-stage fracture fixation and enchondroma curettage.[4,10,11] However, it has not been investigated whether fixation with fixatives is necessary for minimally displaced or undisplaced cases. In this study, we aimed to report the treatment outcomes of non- or minimally displaced pathologic fractures in enchondroma with early one-stage surgery and autogenous bone grafts alone, without metal fixation.

METHODS

The Institutional Review Board of CHA Bundang Medical Center approved the study protocol (IRB No. 2023-09-030). Written informed consent was obtained from the patients in compliance with ethical guidelines.

Patient Demographics

A retrospective analysis of medical records was conducted to investigate patients with enchondroma and pathologic fractures in the hand who underwent surgery at a single institution from January 2010 to December 2021. Initially, a total of 58 cases were screened, and after serial exclusions, 34 cases were included in the study. All patients had confirmed pathologic fractures on preoperative computed tomography (CT) scans. A pathologic fracture was defined as the presence of at least 1 loss of cortical continuity observed on a CT scan, and it was diagnosed when agreed upon by 2 experienced orthopedic surgeons (CH and CHO). A minimally displaced fracture was defined as one where at least 1 direction of the cortex remained intact on the CT scan, and surgical reduction of the fragment was not necessary.

The exclusion criteria were as follows: (1) displaced pathologic fracture with a fixation device applied (n = 10), (2) follow-up period less than 2 years (n = 12), and (3) diagnosis of another tumor on final biopsy (n = 2) (Fig. 1).

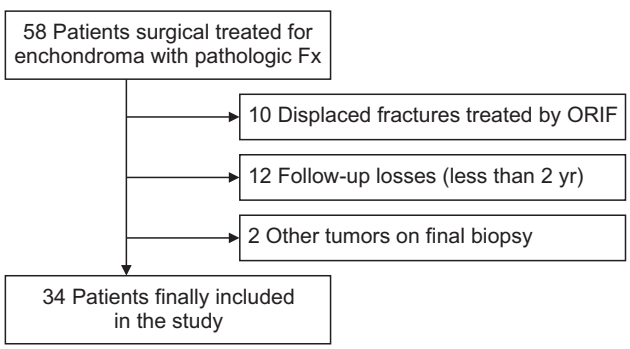

Fig. 1. The flowchart showing the involved patients for this study. Fx: fracture, ORIF: open reduction and internal fixation.

Among the included patients, there were 18 males (52.9%) and 16 females (47.1%). The mean age was 33.6 years (range, 10–61 years). The occurrence locations of enchondroma were as follows: 14 cases (41.2%) in the metacarpals, 10 cases (29.4%) in the proximal phalanges, 6 cases (17.6%) in the intermediate phalanges, and 4 cases (11.8%) in the distal phalanges (Table 1).

Surgical Procedure

The procedure was performed under general anesthesia with the patient in the supine position. The entire affected arm was draped using a pneumatic tourniquet and placed on a radiolucent arm table. The contralateral pelvis was also draped. A longitudinal incision was made on the dorsolateral aspect of the affected bones. The extensor tendons were gently retracted depending on the location of the fracture to ensure proper exposure. Care was taken to avoid displacement of the fracture. An oval-shaped window was created using a Kirschner wire and a small osteotome. Firstly, curettage of the cartilage-like mass inside the medulla was performed, and the specimen was sent to the pathology department for further evaluation (Fig. 2). When the fracture line allowed access to the medulla, we performed curettage without creating an additional window.

Next, an autogenous bone graft was taken from the contralateral anterior superior iliac spine using an osteochondral autograft transfer system (OATS) device (Arthrex). An approximately 2 cm in size skin incision was made to apply OATS devices, and the harvested bone was shaped into chips. The chips were then inserted into the void space. A small impactor was used to ensure a compact and secure bone graft. The cortical window was also fixed with the impactor at the end of the procedure to

Table 1. Demographics and Location of Occurrence of the Enrolled Patients

Demographics	Value
Age (yr)	33.6 (10–61)
Sex (male : female)	18 : 16
Sidedness (right : left)	19 : 15
Location	
Metacarpal	14 (41.2)
Proximal phalanx	10 (29.4)
Intermediate phalanx	6 (17.6)
Distal phalanx	4 (11.8)

Values are presented as mean (range) or number (%).

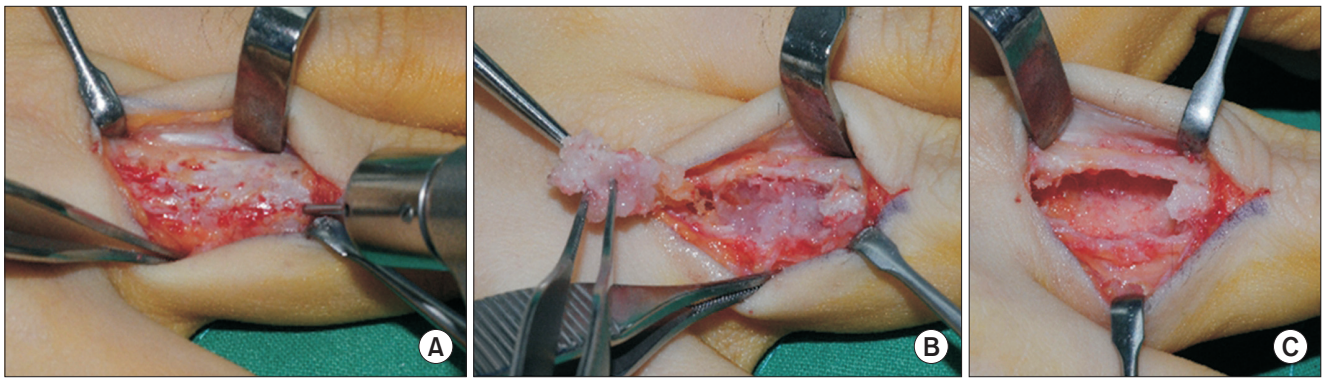

Fig. 2. The surgical procedure on the affected site. (A) Through the dorsolateral approach, an oval-shaped window was created using a Kirschner wire and a small osteotome. (B) Curettage of the cartilage-like mass inside the medulla was done. (C) After curettage, the tumor tissue was all removed and only cortical bone was left.

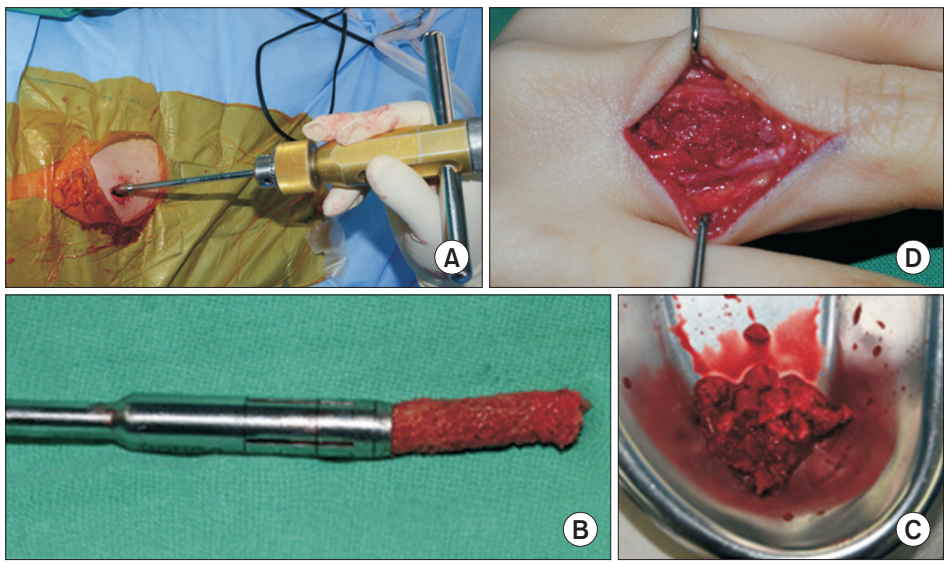

Fig. 3. The surgical procedure of autogenous bone graft. (A) An approximately 2 cm in size cortical bone window was created on the iliac crest. (B) Autogenous bone graft was taken using an osteochondral autograft transfer system device. (C) Harvested bone was shaped into chips. (D) The chips were then inserted into the void space. A small impactor was used to ensure a compact and secure bone graft.

prevent the loss of the transplanted bone (Fig. 3). Careful irrigation was performed to maintain the integrity of the graft. The wound was closed layer by layer using sutures, and a short arm splint was applied.

One week after surgery, the splint was removed, and intermittent range of motion (ROM) exercises were initiated. A detachable brace was worn for additional 3 weeks. Full ROM activities started 4 weeks after surgery. Follow-up visits were scheduled monthly for the first 3 months and then every 6 months thereafter. Patients underwent radiologic evaluation during each visit to confirm fracture healing and tumor recurrence.

Outcome Measurement

Clinical results were evaluated by assessing pain using a visual analog scale (VAS), total finger joint ROM, Disabilities of the Arm, Shoulder, and Hand (DASH) scores, and hand grip strength (GS) at the final follow-up. GS was measured using a Jamar hand dynamometer (Hydraulic Hand Dynamometer 5030 J1, Sammons Preston). After placing the forearm in a neutral position and attaching the elbow to the torso, the patient was asked to pull the gripper handle with maximum force. The GS was compared with the unaffected side, and a 7% correction was made according to dominance, as referenced in a previous study.[12,13]

Radiographic results included fracture union time and investigation of tumor recurrence. We defined bony union as the continuity of trabecular bone in at least 2 simple radiographs. Complications such as soft-tissue infection, joint stiffness, tendon injury, and malunion or nonunion were also evaluated during the follow-up period. Paired *t*-test was conducted to compare the pain VAS and

the number of patients complaining of direct tenderness before and after surgery. In the same way, another paired *t*-test was used to compare GS with the opposite hand at the final follow-up. A $p < 0.05$ was regarded as having statistical significance. We used SPSS version 23 (IBM Corp.) for statistical analysis.

RESULTS

Before surgery, all patients experienced pain at the fracture site, with a mean pain VAS score of 4.5 (range, 3–8). Additionally, 31 patients (91.1%) exhibited direct tenderness, and 22 patients (64.7%) reported limited ROM. After surgery, there was a significant improvement in postoperative pain and tenderness. The average VAS score was 2.3 (range, 0–4), and only 1 patient complained of persistent direct tenderness. The average ROM of the affected joint was 253.8° (range, 240°–260°). There were 3 patients with thumb enchondroma, and their average ROM was 135° (range, 130°–140°) (Table 2). The mean follow-up period was 29.5 months, ranging from 25 to 128 months.

In terms of functional outcomes, the average DASH score was 5.1 (range, 2.5–13.3), and the average GS of the hand was 38.7 kg, which corresponded to 97.8% compared to the unaffected side. Radiographically, all cases achieved successful bony union, with an average time to union of 10.9 weeks. The average time for return to daily activities was 11.8 weeks (Table 3).

The application of the early single-stage autogenous bone graft approach yielded satisfactory results across a range of patients, even for cases involving large-size enchondroma with pathologic fractures (Figs. 4 and 5). No complications such as soft-tissue infection, joint stiffness, or tendon injury were observed. At the final follow-up, there were no cases of malunion, including shortening or rotational deformity, except for 1 instance of suspected recurrence observed at the 9-year postoperative mark, which is being closely monitored (Fig. 6).

Table 2. Pre- and Postoperative Symptoms

Variable	Preoperative	Postoperative	*p*-value
Pain VAS score	4.5 ± 3.4 (3–8)	2.3 ± 3.8 (0–4)	0.013
Tenderness	31 (91.9)	1 (3.1)	< 0.001
Limited ROM	22 (64.7)	0	< 0.001
Total joint ROM (°)	-	253.8 ± 12.8 (240–260)	

Values are presented as mean ± standard deviation (range) or number (%).
VAS: visual analog scale, ROM: range of motion.

DISCUSSION

In this study, we evaluated the surgical outcomes of 34 patients who underwent early one-stage surgery using autogenous bone grafts alone, without the use of metal fixation. Our clinical results demonstrated favorable outcomes without complication. The timing of surgical intervention for enchondroma with associated pathologic fractures has long been a topic of debate.[6,7,9] Historically, delayed treatment following fracture union has been the preferred approach.[6,7] Ablove et al.[6] reported favorable outcomes with delayed treatment, and Yasuda et al.[7] echoed similar results. However, these studies were conducted in the early 2000s, and recent research has predominantly favored early one-stage surgery.[4,9,10]

The discussion about what to use to fill the void after tumor curettage within the intramedullary space is as ongoing as the timing of surgery.[5,14,15] Various approaches have been attempted, including the use of autogenous bone grafts,[4] allografts,[5] or artificial bone substitutes.[16,17] For instance, Bickels et al.[17] utilized nonabsorbable polymethyl-methacrylate, while Joosten et al.[16] employed injectable calcium phosphate cement. In our study, we opted for autologous cancellous bone grafts. Although concerns about donor site morbidity are recognized with autologous grafts,[18] we successfully overcame this issue by employing an OATS device, which necessitated only a small incision for harvesting. None of our patients reported donor site morbidity at the final follow-up. Furthermore, autologous cancellous bone grafts not only demonstrated conduction ability but also exhibited an inductive effect on fracture healing.[19] Additionally, the impacted cancellous bone could provide mechanical stability, which led to no need for fixation during surgery.[11]

Table 3. Postoperative Outcomes, Including Clinical Scores and Radiologic Results

Variable	Value
DASH score	5.1 ± 6.9 (2–13.3)
Grip strength (kg)	38.7 ± 13.8 (97.8)
Grip strength of the contralateral hand (kg)	39.6 ± 15.8*
Mean follow-up period (mo)	29.5 ± 66.4 (25–128)
Time to union (wk)	10.9 ± 6.5
Time to return to daily activities (wk)	11.8 ± 9.7

Values are presented as mean ± SD (range or %) or mean ± SD.
DASH: Disabilities of the Arm, Shoulder, and Hand, SD: standard deviation.
*$p = 0.658$.

Fig. 4. A 19-year-old woman with a large enchondroma on the right third metacarpal shaft. (A, B) Preoperative plain radiograph and computed tomography scan showing nondisplaced pathologic fractures with cortical thinning of the enchondroma. (C) Immediate postoperative plain radiograph showing autogenous bone graft without fixation. (D) Fracture union was confirmed by plain radiography 2 years after surgery without tumor recurrence. (E) At the final clinical follow-up, the interphalangeal and metacarpophalangeal joints showed a satisfactory range of motion.

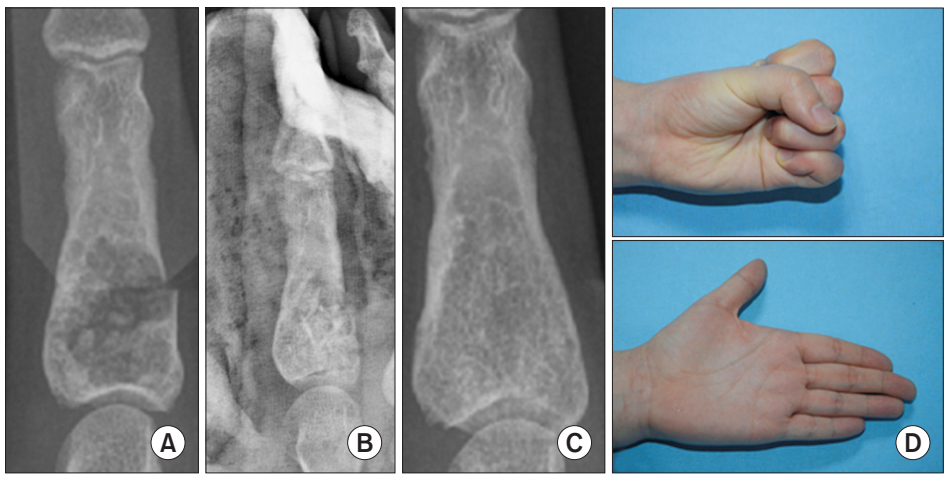

Fig. 5. A 33-year-old man with a large enchondroma on the left second proximal phalanx base. (A) Preoperative plain radiograph showing minimally displaced pathologic fractures with cortical thinning of the enchondroma. (B) Immediate postoperative plain radiograph showing autogenous bone graft without fixation. (C) Fracture union was confirmed by plain radiography 2 years after surgery without tumor recurrence. (D) At the final clinical follow-up, the interphalangeal and metacarpophalangeal joints showed a satisfactory range of motion.

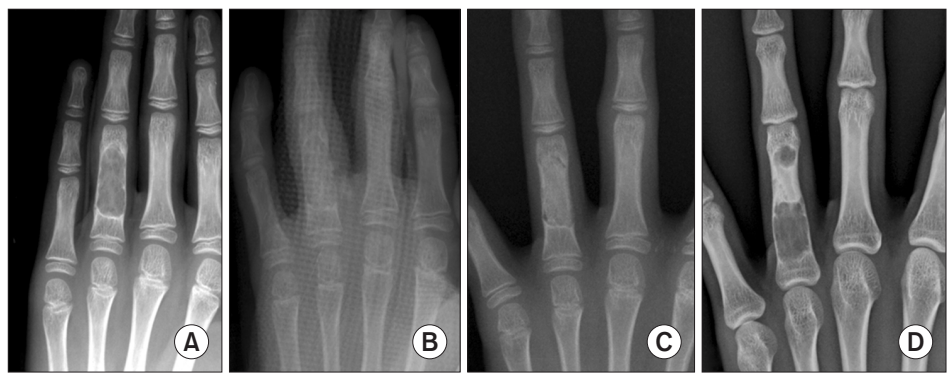

Fig. 6. A 10-year-old boy with a enchondroma on the left fourth proximal phalanx shaft. (A) Preoperative plain radiograph showing nondisplaced pathologic fractures with cortical thinning due to the enchondroma. (B) Immediate postoperative plain radiograph showing autogenous bone graft without fixation. (C) Fracture union confirmed by plain radiography 1 year after surgery. (D) A recurrence of the tumor at the surgical site was discovered after an accident 9 years after surgery. He has no symptoms and is under close follow-up.

Studies investigating enchondromas with pathologic fractures that did not use internal fixation are rare. Lin et al.[11] employed injectable calcium sulfate cement to achieve mechanical stability without fixation in their research. They reported a feasible early ROM and favorable outcomes. Given that hands are not load-bearing lesions, and postoperative splint application is convenient, it is reasonable to assume that adequately filling the intramedullary

space offers sufficient strength for stabilization in cases of minimally displaced fractures. Nevertheless, the absence of biomechanical studies evaluating the mechanical strength of impacted cancellous grafts is a notable limitation.

The absence of well-established treatment guidelines for enchondroma with pathologic fractures can be attributed to the lack of a comprehensive classification system, which complicates the determination of treatment strategies. Although Takigawa[20] introduced a classification based on enchondroma morphology in 1971, there has been no further research on this classification method for over half a century. This classification is intuitive as it is based on the location and shape, but it does not account for pathologic fractures, and it is difficult to predict the prognosis or surgical approach for each type. Furthermore, with the increasing trend toward earlier diagnosis in modern times, classifying tumors based on the extent of progression at the time of diagnosis has become less meaningful. Therefore, future research should focus on reevaluating the classification of enchondroma and pathologic fractures to propose a classification system that can guide surgical strategies.

In our study, there was only 1 patient with tumor recurrence. This patient was a 10-year-old boy who initially showed a favorable outcome after surgery. However, after 9 years, recurrence was diagnosed incidentally during a routine radiographic examination for unrelated reasons. There was no recurrence in locations other than the phalanx. Currently, the patient remains asymptomatic and is under closed observation, but there is a possibility of reoperation. In cases like this, where the onset occurs at a young age and there is significant residual growth potential, caution is advised as recurrence may occur even after a long period after surgery.[21]

The advantages of our surgical approach include the ability to shorten the treatment period with a one-stage procedure and reduce metal-related complications by not using fixatives. However, the term "minimal displaced fracture" can be subjective, so careful consideration is needed when establishing indications for surgical treatment. This study benefited from the consistent performance of all procedures by the same experienced surgeon, reducing confounding factors. Moreover, hand GS was objectively measured. However, there are limitations to consider, including the retrospective nature of the study without a comparison group. Additionally, the study's sample size was relatively small. And no previous mechanical strength study was researched.

In conclusion, our study demonstrated satisfactory results with early single-stage surgical treatment involving curettage of the tumor and autogenous bone graft without fixation in patients with non- or minimally displaced pathologic fractures of enchondroma. This non-fixative technique offers a viable surgical option to shorten the treatment period and minimize implant-related morbidity.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. Figl M, Leixnering M. Retrospective review of outcome after surgical treatment of enchondromas in the hand. Arch Orthop Trauma Surg. 2009;129(6):729-34.
2. 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(6):1229-34.
3. Gaulke R. The distribution of solitary enchondromata at the hand. J Hand Surg Br. 2002;27(5):444-5.
4. Li Q, Kim J, Kim SY, Baek GH. Early surgical treatment of both tumor and fracture in patients with enchondroma of the hand combined with pathologic fracture. Ann Plast Surg. 2021;87(3):260-4.
5. Bauer RD, Lewis MM, Posner MA. Treatment of enchondromas of the hand with allograft bone. J Hand Surg Am. 1988;13(6):908-16.
6. Ablove RH, Moy OJ, Peimer CA, Wheeler DR. Early versus delayed treatment of enchondroma. Am J Orthop (Belle Mead NJ). 2000;29(10):771-2.
7. Yasuda M, Masada K, Takeuchi E. Treatment of enchondroma of the hand with injectable calcium phosphate bone cement. J Hand Surg Am. 2006;31(1):98-102.
8. Riester S, Ramaesch R, Wenger D, van Wijnen A, Kakar S.

Predicting fracture risk for enchondroma of the hand. Hand (N Y). 2016;11(2):206-10.

9. Zhou X, Zhao B, Keshav P, Chen X, Gao W, Yan H. The management and surgical intervention timing of enchondromas: a 10-year experience. Medicine (Baltimore). 2017;96(16):e6678.
10. Zheng H, Liu J, Dai X, Schilling AF. Modified technique for one-stage treatment of proximal phalangeal enchondromas with pathologic fractures. J Hand Surg Am. 2014;39(9):1757-60.
11. Lin SY, Huang PJ, Huang HT, Chen CH, Cheng YM, Fu YC. An alternative technique for the management of phalangeal enchondromas with pathologic fractures. J Hand Surg Am. 2013;38(1):104-9.
12. Richards RR, Gordon R, Beaton D. Measurement of wrist, metacarpophalangeal joint, and thumb extension strength in a normal population. J Hand Surg Am. 1993;18(2):253-61.
13. Leong DP, Teo KK, Rangarajan S, et al. Reference ranges of handgrip strength from 125,462 healthy adults in 21 countries: a prospective urban rural epidemiologic (PURE) study. J Cachexia Sarcopenia Muscle. 2016;7(5):535-46.
14. Tordai P, Hoglund M, Lugnegard H. Is the treatment of enchondroma in the hand by simple curettage a rewarding method? J Hand Surg Br. 1990;15(3):331-4.
15. Bachoura A, Rice IS, Lubahn AR, Lubahn JD. The surgical management of hand enchondroma without postcurettage void augmentation: authors' experience and a systematic review. Hand (N Y). 2015;10(3):461-71.
16. Joosten U, Joist A, Frebel T, Walter M, Langer M. The use of an in situ curing hydroxyapatite cement as an alternative to bone graft following removal of enchondroma of the hand. J Hand Surg Br. 2000;25(3):288-91.
17. Bickels J, Wittig JC, Kollender Y, et al. Enchondromas of the hand: treatment with curettage and cemented internal fixation. J Hand Surg Am. 2002;27(5):870-5.
18. Younger EM, Chapman MW. Morbidity at bone graft donor sites. J Orthop Trauma. 1989;3(3):192-5.
19. Graham SM, Leonidou A, Aslam-Pervez N, et al. Biological therapy of bone defects: the immunology of bone allotransplantation. Expert Opin Biol Ther. 2010;10(6):885-901.
20. Takigawa K. Chondroma of the bones of the hand: a review of 110 cases. J Bone Joint Surg Am. 1971;53(8):1591-600.
21. Gaulke R, Suppelna G. Solitary enchondroma at the hand: long-term follow-up study after operative treatment. J Hand Surg Br. 2004;29(1):64-6.