 Acta Chir Orthop Traumatol Cech., 91, 2024, No. 6, p. 331–338
DOI: 10.55095/ACHOT2024/067

ORIGINAL PAPER
PŮVODNÍ PRÁCE

Hand Enchondromas Treated with Curettage: a Single Institution Experience and Literature Review

Enchondromy ruky léčené kyretáží: zkušenosti jedné instituce a přehled literatury

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ABSTRACT

PURPOSE OF THE STUDY

Hand enchondromas are benign cartilage bone tumors. Curettage represents the actual gold standard for hand enchondromas. Little has been written about the effectiveness of curettage on hand functionality.

MATERIAL AND METHODS

In this retrospective study, we evaluated the effectiveness of curettage and bone grafting on the hand. For each case, we compared the pre-operative and post-operative QuickDASH of the treated limb. The final functional outcome was also evaluated by calculating the affected finger's Total Active Movement (TAM). Complications and local recurrences were recorded.

RESULTS

Forty-five cases were included in our study. Fifteen of them had a pathological fracture. The mean pre-operative QuickDASH score was 48.4. No intraoperative complications occurred. After a mean follow-up of 38.1 months, the mean QuickDASH score had decreased to 4.4, and the TAM was optimal or sub-optimal. QuickDASH and TAM were significantly better for those with pathologic fractures before surgery. Only 3 cases (7%) had postoperative complications, and 1 (2%) had a local recurrence.

DISCUSSION

Our results prove the effectiveness of curettage and early rehabilitation in increasing and restoring the performances of the treated hands. Our patients experienced a significant improvement in their functionality after surgery, generally passing from a poor to an excellent status. In our cohort, those who had a pathologic fracture before surgery had slightly but significantly worse functional outcomes compared to those who did not suffer pre-operative lesions.

CONCLUSIONS

Curettage and early postoperative rehabilitation can lead to good clinical and functional outcomes for hand enchondromas. Patients with pathologic fractures, although slightly exposed to a higher risk of sub-optimal outcomes, can also aim for good post-operative functionality.

Key words: hand, chondroma, QuickDASH, fracture, rehabilitation.

INTRODUCTION

Chondroma represents one of the most common primary benign bone tumors of the hand. The chondroma is uniformly composed of well-differentiated and mature hyaline cartilage that usually originates from proliferating chondrocytes of the epiphyseal cartilage plate of the metaphysis, which can eventually become diaphyseal with skeletal growth. Their most common localization is the diaphysis of the small, long bones of the hand, followed by other bones such as the femur and humerus. Solitary chondromas, particularly enchondromas, often grow slowly, and their transformation in chondrosarcomas is rare (18, 25).

Often asymptomatic and painless, enchondromas are frequently the object of incidental diagnosis. Pain can be caused by pathologic fractures, strenuous exercise (unapparent stress fractures), or, mainly in children and adolescents, intense metabolic activity (27).

X-rays are mandatory to make a presumptive diagnosis of chondroma. Radiographically, enchondromas appear as well-defined central lytic lesions involving diaphysis or metaphysis, where the cortex is usually well-preserved. A thin rind of reactive sclerosis marks these lesions that frequently contain opacities with "pop-corn" or "ring-like" shapes (16, 18, 25, 27).

Most chondromas do not require surgical treatment due to their slow growth and low incidence of malignant degeneration. Surgical approaches are recommended mainly for symptomatic patients and when imaging cannot exclude a malignant nature of the mass (9). The gold standard for the surgical treatment of hand enchondromas consists of curettage, which could eventually be associated with local adjuvants, and the subsequent filling of the resulting cavity with bone allografts or other scaffolds to restore bone continuity (17). Although literature flourished with evidence regarding local recurrences and complications' risk after the curettage of hand enchondromas (18, 10–17, 19–24, 26, 29–34) there is still a paucity of studies that evaluated the clinical and functional outcomes of treated patients (5, 7, 10 17, 20, 22, 33).

In this paper, we report our experience in the surgical treatment of enchondromas of the hand, evaluating patients' symptoms and their hands' functionality before and after surgery and assessing the impact of the disease and the effects of surgical treatment on patients' daily lives.

MATERIAL AND METHODS

This single-center retrospective study was performed following the ethical standards of the 1964 Declaration of Helsinki and its later amendments.

Our study consisted of a review of all the patients who had been diagnosed with enchondromas of the hand bones and were treated using curettage and bone grafting in our institution between September 2016 and September 2022. For each patient we collected personal data including age and gender. In case of pain, swelling or functional limitations attributable to the disease, cases were asked to identify their first symptom and the time interval between its onset and the first radiological evidence of an osteolytic lesion within their bone (diagnostic delay). Each patient underwent pre-operative X-rays, MRI and CT scans, which were used to orient the diagnosis, guide surgical planning and estimate the tumor size (Fig. 1).

In case of a pre-operative pathological fracture, cases were immobilized in a Zimmer cas and underwent surgery as soon as they showed radiographic signs of bone fracture healing. Surgical specimens obtained during curettage were examined by a pathologist to confirm the diagnosis of enchondroma. For each patient, the pre-operative functionality of the affected limb was

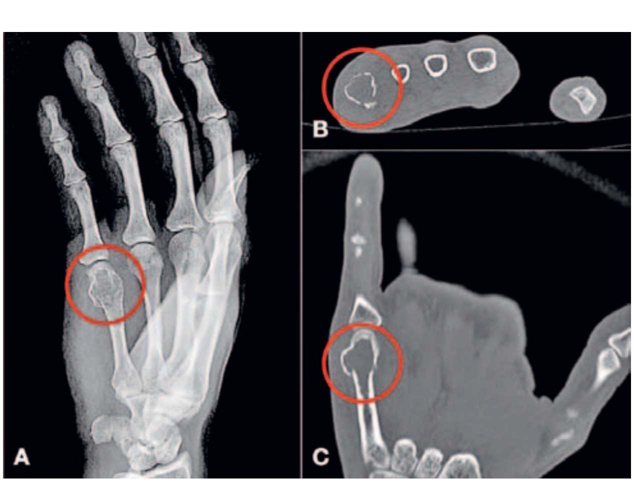

Fig. 1. Pre-operative X-ray (A) and CT scans (B, C) of a case with a metacarpal enchondroma before surgical treatment.

Fig. 2. An intra-operative image of a case with an hand enchondroma of the II proximal phalanx. The cortical window has altready been removed, and the lytic lesion has just been curetted. The resulting cavity is displayed and ready to be filled with graft.

evaluated using the QuickDASH score at the moment of their hospitalization. The total active movement (TAM) of the affected finger was calculated.

Surgical procedure

Once in the operative theater, patients are positioned on a radiolucent surgical table in supine position. A pneumatic tourniquet is set at the limb root and inflated before surgical incision. Surgical approach to metacarpal enchondromas has been carried out through a dorsal-lateral incision, while protecting the extensor tendons and the sagittal bands. The enchondromas that involved proximal and middle phalanxes have been approached with dorsolateral incisions, taking care to avoid damages to the central slip, lateral bands or the nearby neuro-vascular bundles. For the distal phalanx, a mid-lateral approach has been preferred to a dorsal one in order to avert injuries of the nail apparatus. Once the bone surface has been exposed, narrow swing saws or ultrasonic vibrators are used to perform linear osteotomies and shape a small window through the cortex (Fig. 2).

Using a lever, the window of cortical bone is removed and the enchondroma can be visualized, appearing as a pearly white soft mass. A vigorous curettage is then started with Volkmann spoons and completed using a high-speed burr. The tissue removed is preserved for further histological examinations. Alcoholization of the cavity's surfaces was carried out in order to minimize the risk of local recurrences. The cavity was then filled with compressed allogeneic bone chips which had been previously immersed in a rifampicin solution. These grafts were used to induce osteointegration, provide better mechanical resistance and theoretically reduce the risk of post-operative fractures. The cortical bone window was then set back in its position and fibrin glue was used to restore the continuity of the cortical bone.

Finally, the tourniquet was deflated and local hemostasis was checked before suturing the surgical access. The treated finger was then patched up and temporarily immobilized in a Zimmer cast.

Intra-operative fluoroscopy was used to identify the lesions, check the completion of the curettage and the final result at the end of the whole procedure.

Rehabilitation and post-operative follow-up

During the first two weeks after surgery, the treated finger was immobilized in a long Zimmer splint. Patients were encouraged to keep their hands up and move actively and passively the articulations that were left free in order to minimize the risk of edema. After two weeks, the splint was removed and physical rehabilitation was started. Each case was guided to practice daily active and passive mobilization of their fingers to avoid disuse atrophy and post-operative stiffness. Periodical massages with elasticizing creams containing hyaluronic acid were practiced on the surgical site to prevent scar adhesions.

Light weight bearing was not allowed in any case before 30 days after surgery. Heavy weight bearing, sport practice and traumatic activities were allowed after 60 days or anyway after radiographic signs of advanced bone consolidation.

In the months that followed the surgical intervention, our patients underwent serial office visits, clinical evaluations and X-rays to assess the grade of bone healing. Each complication with grade II or higher according to the Clavien-Dindo classification was reported. Within 12 months after surgery, the radiographic healing grade was calculated according to the Tordai classification. For each patient, the post-operative functionality of the affected limb was evaluated using the QuickDASH score at their latest follow-up. The affected finger's total active movement (TAM) was also calculated and compared to the pre-operative one.

Statistical analysis was performed using Stata SE 13 (StataCorp LLC, College Station, TX). Statistical significance was set at 0.05 for all endpoints.

RESULTS

Between September 2016 and September 2022, 45 patients were diagnosed in our institution with enchondromas of the hand bones and treated with curettage and bone grafting. There were 23 females and 22 males. Their mean age was 36.4 (9–76). The tumor involved the metacarpal bones in 10 cases, proximal phalanxes in 18 cases, middle phalanxes in 13 cases, and distal phalanxes in 4 cases. Fifteen patients came to our attention with a pathological fracture. On average, fractured bones required 22 (13–33) days to have adequate signs of fracture healing and be treated with curettage. In the other eleven cases, lesions were recognized incidentally before the onset of the first symptoms. Among the remaining 19 cases, the diagnosis was established 4.1 (1–12) months after the onset of the first symptom. The most common onset symptoms were pain (16 cases) and swelling (3 cases).

The mean pre-operative QuickDASH score was 48.4 (9–75).

No intraoperative complications occurred through the surgical interventions.

The mean follow-up was 38.1 (15–94) months. One case suffered from a fracture three months after our interventions, which required surgical fixation. Two cases had infections of the superficial soft tissues that were successfully treated with oral antibiotics. All three cases who suffered from post-operative complications had pre-operative fractures. The remaining 42 cases (93%) had been complications-free at their latest follow-up. One case of local recurrence was diagnosed 24 months after surgery. The osteolytic lesion, localized to a proximal phalanx, was treated with the same methods that had been used for the first surgical approach, consisting of further curettage and bone grafting. Histological evaluations confirmed the diagnosis of recurrent enchondroma, without any malignant degeneration. Twenty-eight months later, the patient's imaging and clinical evaluations showed no evidence of disease (NED). The remaining 44 cases (98%) have been continuously disease-free (CDF).

Within 12 months after the curettage, 80% (36) of our cases had a grade I radiographic healing according to the Tordai classification. The remaining 20% (9) of our cases had a grade II appearance.

Our mean post-operative QuickDASH score was 4.4 (0–29). This value was significantly lower than the one recorded before surgery, as testified by a two-tailed t-student test ($p=0.001$). This difference testified to the global effectiveness of our treatment. Thirty-four of our cases had excellent outcomes (QuickDASH < 5), whereas the remaining eleven cases had a QuickDASH score higher than 5. Among these latter, eight were treated after a pathologic fracture. A Fisher Exact Test showed that, in our cohort, patients with a pre-operative fracture were most likely to obtain suboptimal results ($p=0.003$). A t-student test also highlighted that the post-operative QuickDASH scores of cases with pre-operative fractures were significantly higher than the ones of the other patients ($p=0.023$)

At their latest follow-up, the patient's mean total active movement (TAM) was 133.3° (120–140) for the thumb and 238.5° (215–250) for the other fingers. These ranges were significantly lower for cases with a pathologic fracture before surgery, as testified by a t-student test ($p=0.038$).

Differences between patients who had a pathologic fracture before surgery and the rest of our cohort were reported in Table 1.

Table 1. Overview of our cases, with total cases, those who did not have pre-operative fractures and those who had a fracture at the moment of their hospitalization

	TOTAL	NO PRE-OP FRACTURE	PRE-OP FRACTURE
Cases (N)	**45**	**30**	**15**
Metacarpus	10	6	4
Proximal Phalanx	18	11	7
Middle Phalanx	13	10	3
Distal Phalanx	4	3	1
Pre-Operative QuickDASH	**48.4**	**45.1**	**55**
Post-Operative QuickDASH	**4.4**	**1.5**	**10.2**
Complications (N)	**3 (6.7%)**	**0**	**3 (20%)**
Infections	2 (4.4%)	0	2 (13.3%)
Fractures	1 (2.2%)	0	1 (6.7%)
Local recurrence (N)	**1 (2.2%)**	**1 (3.3%)**	**0**
TAM I Ray	**133°**	**137°**	**125°**
TAM II-V Ray	**238°**	**243°**	**228°**

TAM = Total Active Movement

DISCUSSION

Curettage represents the gold standard for the surgical treatment of hand enchondromas. Since the dawn of the new millennium, modern literature has bloomed with new articles testifying technical variations of the surgical approach and reporting the outcomes of surgical and post-operative treatments (1-8, 10–17, 19-24, 26, 29–34). A summary of modern literature is pictured in Table 2.

Despite some differences, most of the authors described similar techniques of curettage, performed mainly using Volkmann spoons and high-speed burrs. Only a few authors consistently used local adjuvants such as phenol (7), alcohol (3), or hydrogen peroxide (17). Literature supports the idea that a careful curettage should always be performed to minimize the risk of post-operative local recurrence in the months and years that follow surgical interventions (6). Many authors evaluated large cohorts without a single local recurrence, and none of the studies since 2000 reported a recurrence rate higher than 16% (19). Unlike other locally aggressive lesions, local recurrences of hand enchondromas are often diagnosed several years after sur-

Table 2. Resume of modern literature about curettage for hand enchondromas. The reported articles are the result of a combined research on the catalogs of PubMed, Scopus and Google scholar, searching for the words "hand", "chondroma" or "enchondroma" and "curettage". Only studies published and indexed between 2000 and 2023 were included in our list. Case reports were excluded, as well as articles written in a language other than English.

Article	Year	Cases (N)	Age (y)	Pathol. fractures (%)	Filling	LR	Complic..	Pre-op function	Post-op function	FU (m)
Joosten et al. (11)	2000	8	35	/	BS	0	0	/	/	12+
Montero et al. (14)	2001	21	32	23.8%	Autograft	1 (4.8%)	0	/	/	/
Bickels et al. (2)	2002	13	32	61.5%	Cemented hardware	0	0	/	/	73
Goto et al. (8)	2002	23	39	17.4%	Autograft / None	0	0	/	/	6+
Yercan et al. (31)	2004	76	32	51.3%	(61) Autograft (15) Allograft	3 (3.9%)	12 (15.8%) 10 donor site pain 2 infections	/	/	147
Gaulke & Suppenna (6)	2004	21	39	42.9%	Allograft	3 (14.3%)	8 (38%) 8 stiffness	/	/	108
Gaasbeek et al. (5)	2005	17	41	47.4%	BS	0	0	/	MSTS 29.0	53
Yasuda et al. (30)	2006	10	31	50%	BS	0	1 (10%) 1 mal-union	/	/	41
Schaller & Baer (24)	2009	16	42	43.7%	(8) Autograft (8) None	0	/	/	/	68
Morii et al. (15)	2010	29	38	48.3%	None	0	0	/	/	24
Kim et al. (12)	2012	10	39	20%	BS	0	0	/	/	19

Sassoon et al. (23)	2012	80	29	51.2%	(54) Autograft (40) Allograft/ BS (8) None	6 (7.5%)	15 (18.7%) 3 extensor tendon adhesion 1 neuroma 5 wound infection 1 swan-neck deformity 2 fractures 1 incisional numbness 1 metacarpal shortening 1 ulnar deviation	/	/	38
Choy et al. (4)	2012	18	35	5.5%	BS	0	0	/	/	32
Lin et al. (13)	2013	8	24	100%	BS	0	0	/	/	19
Rabarin et al. (21)	2014	24	41	0	None	1 (4.2%)	0	/	/	88
Zheng et al. (32)	2014	9	28	100%	Autograft	0	0	/	/	30
Bachoura et al. (1)	2015	24	39	54.2%	None	1 (4.2%)	2 (8.3%) 1 swan neck deformity 1 joint contracture	/	/	26
Cha et al. (3)	2015	62	37	–	None	0	0	/	/	41
Georgiannos et al. (7)	2015	82	22	14.6%	BS	0	0	/	MSTS 29.5	60+
Hung et al. (10)	2015	24	40	41.7%	(13) Autograft (11) BS	1 (4.2%)	2 (8.3%) 1 infection 1 foreign body reaction	/	DASH 3.8	59
Rajeh et al. (22)	2016	8	44	25%	BS	0	1 (12.5%) 1 Cement leakage	DASH 37.7	DASH 24.1	16
Zhou et al. (33)	2018	92	29	29.3%	(37) Autograft (29) Allograft/ BS (26) None	0	18 (19.6%) 17 persistent pain 1 infection	/	DASH 12.6	6+
Sollaci et al. (26)	2019	48	34	31.2%	Autograft	1 (2.1%)	2 (4.2%) 1 fracture 1 limited ROM	/	/	59
Wessel et al. (29)	2021	104	35	30.5%	Allograft	5 (4.8%)	3 (2.9%) 3 excessive wound sensibility	/	/	37
Nazarova et al. (17)	2021	200	40	35.5%	(100) Autograft (100) BS	6 (3%)	21 (10.5%) 7 infections 5 persistent pain 4 stiffness 5 fracture	/	DASH 3.8	30
Zyluk (34)	2021	24	31	16.7%	(15) Autograft (5) BS	2 (8.3%)	4 (16.7%) 3 infections 1 reaction to bone substitute	/	/	24
Orman et al. (19)	2022	25	35	20%	Autograft	4 (16%)	0	/	/	12+
Park et al. (20)	2023	88	38	0	Allograft	1 (1.1%)	0	DASH 2.1 MSTS 25.4	DASH 1.6 MSTS 29.9	122
Current study		45	36	33.3%	Allograft	1 (2.2%)	3 (6.7%) 2 infections 1 fracture	DASH 48.4	DASH 4.4	38

BS = Bone substitute Autograft / Auto = Autologous cancellous bone Allograft / Allo = Allogenetic cancellous bone gery (1, 10, 14, 23). This evidence should encourage physicians to extend radiographic follow-up to avoid misdiagnosed local recurrences (14). Our local recurrence rate of 2.2% confirms the reasonable local control of the disease, thereby testifying to the effectiveness of an accurate curettage alone for eradicating neoplastic cells from the treated area.

Once the curettage has been carried out, surgeons can leave the resulting cavity or fill it with bone or bone substitutes. Some authors obtained promising clinical and radiographic results and reasonable fracture rates despite avoiding local grafting (1, 3, 8, 15, 23, 24). However, most of the authors opted to fill the curettage cavity with either bone grafts or other local substitutes to immediately improve the mechanical stability of the curetted area and eventually provide a helpful scaffold for bone cells to recolonize the area (2, 4–7, 10-14, 16, 17, 19, 20, 22, 26, 29–34). While cement and other inorganic bone substitutes (2, 4, 5, 7, 10-14, 17, 22, 23, 30, 34) mainly play a mechanical role as fillers, autologous (8, 10, 14, 17, 19, 23, 24, 26, 31, 33, 34) and allogeneic cancellous bone grafts (6, 23, 28, 29, 31, 33, 34) can also enhance local osseointegration. In particular, autologous bone grafts provide vital bone tissue, theoretically leading to the best osseointegration and playing an osteoinductive role since the first steps of the healing process in the receiving site (28). These properties led to encouraging results in clinical outcomes and imaging evidence, establishing bone autografts as reliable reconstructive options despite the extended surgical times and the risk of pain and infection in their donor site (31).

Although lacking in osteoinductive potential, allogeneic cancellous grafts can provide osseointegration potential without a donor site. This not only abolishes the risk of donor site complications but also leads to reduced surgical times for each intervention. Some authors evaluated the effectiveness of bone allografts after hand curettage using the classification of Tordai which highlights the increment of bone density in the treated bone segments (23, 31). Our population, treated with allograft cancellous bone, showed an excellent post-operative integration, as suggested by our good Tordai scores and our low incidence of post-operative fractures.

Regardless of the filling of choice, literature agrees that curettage of hand enchondromas leads to low risks of complications, with rates ranging between 0 and 38% (1-8, 10–17, 19-24, 26, 29–34). Although rare, infections have been described as the most common complication by Sassoon et al. (6.2% rate) (23), Nazarova et al. (17.5%) (17), and Zyluk (12.5%) (34) . The same Sassoon et al. (5% rate) (23) and Nazarova et al. (2.5%) (17), but also Sollaci et al. (2.1%) (26), testified the occurrence of post-operative fractures in the months that followed curettage. Despite the occurrence of infections (4.4% rate) and post-operative fractures (2.2%), our global incidence of complications was low, confirming hand curettage as a safe procedure for patients who suffer from hand enchondromas.

While disease control and imaging outcomes have been largely described by the vast majority of the research papers published in the current century, less attention has been paid to the functional outcomes (1–8, 10–17, 19–24, 26, 29–34). Only a few articles evaluated the post-operative performances of treated hands using standardized scores such as the Quick DASH or the Musculoskeletal Tumor Society (MSTS) scoring systems (5, 7, 10, 22, 28, 32–34). Gaasbeek et al. (5) in 2004 and Georgiannos et al. (7) in 2015 used the MSTS score to evaluate the outcome of their treatment, testifying an excellent post-operatve functionality of the treated upper limbs and hands. Since 2015, Hung et al. (10), Zhou et al. (33), and Nazarova et al. (17) reported similar outcomes using the QuickDASH scoring system. However, none of the above studies provided information about patients' pre-operative functionality, not allowing any comparison between the pre-operative and post-operative clinical picture. In 2016, Al Rajeh et al. (22) compared the pre-operative and post-operative QuickDASH scores of their eight patients, with six of them who had significant benefits after surgery. In a recent paper, Park et al. (33) evaluated the functionality of their 88 cases with hand enchondromas in detail. The authors reported limited pre-operative pain and functional limitations (MSTS 25.4 and QuickDASH 2.1) that surgical treatment still managed to reduce, as testified by an increment in the mean post-operative MSTS score (29.9) and a reduction in the mean QuickDASH score (1.6). These excellent outcomes have been accompanied by a total or sub-total restoration of the active motion of the treated fingers in the vast majority of their cases.

Our results align with those published by Al Rajeh et al. (22) and Park et al. (20), proving the effectiveness of curettage and early rehabilitation in increasing and restoring the performances of the treated hands. Our patients experienced a significant improvement in their functionality after surgery, generally passing from a poor to an excellent status. In our cohort, those who had a pathologic fracture before surgery had slightly but significantly worse functional outcomes compared to those who did not suffer pre-operative lesions. This finding, inconsistent with what was previously stated by Zhou et al. (33) in 2018, suggests that patients with pathologic fractures who received curettage after a pathologic fracture were more prone to get sub-optimal results. The reason for this discrepancy may lie in the period of immobilization required to ease bone healing. Summing the pre-operative and the post-operative phase, our cases with pathologic fractures were forced to more weeks of immobilization compared to the other cases in our population. Mobilization maintains the articular elasticity and avoids the formation of adherences in the treated area. For this reason, despite the pivotal role of surgery, rehabilitation is fundamental to the success of the whole treatment of hand enchondromas. Surgeons should encourage early and intense mobilization within a few weeks after the curettage to maximize the patient's functional recovery. For cases with pathologic fractures, the treatment should be performed as soon as the fracture gives imaging signs of healing, avoiding further delays in surgical intervention and subsequent physical therapy.

We acknowledge that our study is not free of limitations. One of them is represented by the retrospective nature of our study, which did not allow the complete standardization of the postoperative follow-up procedures for each patient. The small size of our cohort represents another limitation. The low incidence did not allow us to operate with a broader population, and the limited timespan of the investigation did not allow us to evaluate some of our patients with a very long follow-up. These limits could be overcome by performing similar evaluations on a prospective basis and broader populations.

Despite these limitations, our study provides further evidence about the reliability of curettage and allogeneic bone grafting for treating hand enchondromas. Our low risk of recurrence and reasonable complication rates confirm what had been previously highlighted by modern literature. At the same time, our functional outcomes support the effectiveness of adequate surgery followed by early post-operative rehabilitation.

CONCLUSIONS

In conclusion, an accurate curettage and bone grafting, followed by an adequate post-operative rehabilitation, can lead to excellent clinical and functional outcomes for cases with hand enchondromas. Also cases with pre-operative pathologic fractures, although slightly exposed to the risk of sub-optimal outcomes, can aim for good post-operative functionality and the restoration of their previous performance status.

References

1. 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;10:461–471. doi: 10.1007/s11552-015-9738-y.
2. Bickels J, Wittig JC, Kollender Y, Kellar-Graney K, Mansour KL, Meller I, Malawer MM. Enchondromas of the hand: treatment with curettage and cemented internal fixation. J Hand Surg Am. 2002;27:870–875. doi: 10.1053/jhsu.2002.34369.
3. 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;40:384–391. doi: 10.1177/1753193413517204.
4. Choy WS, Kim KJ, Lee SK, Yang DS, Park HJ. Treatment for hand enchondroma with curettage and calcium sulfate pellet (OsteoSet®) grafting. Eur J Orthop Surg. 2012;22:295–299. doi:10.1007/s00590-011-0842-6.
5. Gaasbeek RD, Rijnberg WJ, van Loon CJ, Meyers H, Feith R. No local recurrence of enchondroma after curettage and plaster filling. Arch Orthop Trauma Surg. 2005;125:42–45. doi: 10.1007/s00402-004-0747-5.
6. Gaulke R, Suppelna G. Solitary enchondroma at the hand. Long-term follow-up study after operative treatment. J Hand Surg Br. 2004;29:64–66. doi: 10.1016/j.jhsb.2003.08.003.
7. Georgiannos D, Lampridis V, Bisbinas I. Phenolization and coralline hydroxyapatite grafting following meticulous curettage for the treatment of enchondroma of the hand. A case series of 82 patients with 5-year follow-up. Hand (N Y). 2015;10:111–115. doi: 10.1007/s11552-014-9674-2.
8. Goto T, Yokokura S, Kawano H, Yamamoto A, Matsuda K, Nakamura K. Simple curettage without bone grafting for enchondromata of the hand: with special reference to replacement of the cortical window. J Hand Surg Br. 2002;27:446–451. doi: 10.1054/jhsb.2002.0843.
9. Herget GW, Uhl M, Opitz OG, Adler CP, Südkamp NP, Knöller S. The many faces of chondrosarcoma of bone, own cases and review of the literature with an emphasis on radiology, pathology and treatment. Acta Chir Orthop Traumatol Cech. 2011;78:501–509.
10. Hung YW, Ko WS, Liu WH, Chow CS, Kwok YY, Wong CW, Tse WL, Ho PC. 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;21:217–223. doi: 10.12809/hkmj144325.
11. 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;25:288–291. doi: 10.1054/jhsb.2000.0383.
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. doi: 10.1142/S0218810412500104.
13. 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;38:104–109. doi: 10.1016/j.jhsa.2012.08.045.
14. Montero LM, Ikuta Y, Ishida O, Fujimoto Y, Nakamasu M. Enchondroma in the hand retrospective study--recurrence cases. Hand Surg. 2002;7:7–10. doi: 10.1142/s0218810402000893.
15. Morii T, Mochizuki K, Tajima T, Satomi K. Treatment outcome of enchondroma by simple curettage without augmentation. J Orthop Sci. 2010;15:112–117. doi: 10.1007/s00776-009-1419-7.
16. Mulligan ME. How to Diagnose Enchondroma, Bone Infarct, and Chondrosarcoma. Curr Probl Diagn Radiol. 2019;48:262–273. doi: 10.1067/j.cpradiol.2018.04.002.
17. Nazarova NZ, Umarova GS, Vaiman M, Asilova SU, Abba M, Foonberg M, Shterenshis M. The surgical management of the cavity and bone defects in enchondroma cases: a prospective randomized trial. Surg Oncol. 2021;37:101565. doi: 10.1016/j.suronc.2021.101565.
18. O'Connor MI, Bancroft LW. Benign and malignant cartilage tumors of the hand. Hand Clin. 2004;20:317–323, vi. doi: 10.1016/j.hcl.2004.03.019.
19. Orman O, Adiguzel İF, Sencan A, Baydar M, Orman M, Ozturk A. Comparison of distal radius autograft technique with iliac crest autograft technique in solitary finger enchondromas. Sisli Etfal Hastan Tip Bul. 2022;56:400–407. doi: 10.14744/SEMB.2022.00483.
20. Park HY, Joo MW, Choi YH, Chung YG, Park CJ. Simple curettage and allogeneic cancellous bone chip impaction grafting in solitary enchondroma of the short tubular bones of the hand. Sci Rep. 2023;13:2081. doi: 10.1038/s41598-023-29130-w.
21. Rabarin F, Laulan J, Saint Cast Y, Césari B, Fouque PA, Raimbeau G. Focal periosteal chondroma of the hand: a review of 24 cases. Orthop Traumatol Surg Res. 2014;100:617–620. doi: 10.1016/j.otsr.2014.05.014.
22. 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;27:251–254. doi: 10.1007/s00590-016-1888-2.
23. 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;37:1229–1234. doi: 10.1016/j.jhsa.2012.03.019.
24. Schaller P, Baer W. Operative treatment of enchondromas of the hand: is cancellous bone grafting necessary? Scand J Plast Reconstr Surg Hand Surg. 2009;43:279–285. doi: 10.3109/02844310902891570.

25. Simon MJ, Pogoda P, Hövelborn F, Krause M, Zustin J, Amling M, Barvencik F. Incidence, histopathologic analysis and distribution of tumours of the hand. BMC Musculoskelet Disord. 2014;15:182. doi: 10.1186/1471-2474-15-182.
26. Sollaci C, Araújo GCS. Enchondromas of the Hand: A 20-year experience. Rev Bras Ortop (Sao Paulo). 2019;54:714–720. doi: 10.1055/s-0039-1697970.
27. Strike SA, Puhaindran ME. Tumors of the hand and the wrist. JBJS Rev. 2020;8:e0141. doi: 10.2106/JBJS.RVW.19.00141. PMID: 32487977.
28. Wang W, Yeung KWK. Bone grafts and biomaterials substitutes for bone defect repair: a review. Bioact Mater. 2017;2:224–247. doi: 10.1016/j.bioactmat.2017.05.007.
29. Wessel LE, Christ AB, Athanasian EA. Impact of patient and tumor characteristics on range of motion and recurrence following treatment of enchondromas of the hand. J Hand Surg Am. 2023;48:512.e1–512.e7. doi: 10.1016/j.jhsa.2021.11.027.
30. 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. doi: 10.1016/j.jhsa.2005.08.017.
31. Yercan H, Ozalp T, Coşkunol E, Ozdemir O. Long-term results of autograft and allograft applications in hand enchondromas. Acta Orthop Traumatol Turc. 2004;38:337–342.
32. 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;39:1757–1760. doi: 10.1016/j.jhsa.2014.06.131.
33. 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:e6678. doi: 10.1097/MD.0000000000006678.
34. Żyluk A. Outcomes of Surgery for Enchondromas within the Hand. Ortop Traumatol Rehabil. 2021;23:325–334. doi: 10.5604/01.3001.0015.4344.

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