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Hand enchondromas: surgical treatment and function outcomes in a case series

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Summary

Objective. Hand enchondromas are benign cartilage bone tumors. Surgical treatment is recommended both in case of functional impairment or suspicion of malignant degeneration. Curettage and bone grafting are held to be a safe and reliable procedure to treat hand chondromas. Nevertheless, little has been written about the effectiveness of surgical treatment on hand functionality and its consequences of patients' return to sport.
Methods. In this retrospective study we evaluated 21 cases of hand enchondroma treated with curettage and bone grafting. We evaluated and compared patients' pre-operative and post-operative functional outcomes and monthly frequency of sport activity.
Results. Our outcomes were in line with the literature in terms of safety and local effectiveness of curettage and bone grafting. In fact, post-operative complications and local recurrence were limited to only 4.8% (1/21). Furthermore, patients saw improvements in mean QuickDASH score and frequency of sport practice.
Conclusions. Our outcomes therefore suggest that a surgical approach, associated with early physical therapy, can successfully restore hand functionality, with positive implications on autonomy activities of daily living.

Key words: enchondroma, chondroma, hand, functionality, sport

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Introduction

Chondroma is a benign bone tumor composed of mature hyaline cartilage. It represents the second most common benign bone tumor following osteochondroma and the most common primary bone tumor of the hand [1-3]. Generally located in long bones, chondromas can be classified according to their localization relative to the native bone. Cartilaginous lesions which are centrally located in the bone are called enchondromas, while those which are more eccentric are called periosteal chondromas. Although rare, chondromas can also be located outside of bones and involve soft tissue, taking the name of extraosseous chondromas. Chondromas, and enchondromas in particular, are believed to originate from fragments of cartilage detached from growing plates and entrapped inside the medullary canal [4].
Hand enchondromas are more frequently diagnosed between the 2nd and the 4th decade of life, without significant gender preference [5]. Their most common localization is represented by the diaphysis of the small long bones of the hand, followed by other bones in other anatomical districts such as femur and humerus. In particular, the tumor significantly favors proximal phalanges over the other bones of the hand and involves the 5th ray with a higher frequency [6-8].

Enchondromas often stay asymptomatic for years and decades, being often the object of incidental diagnosis. However, a small percentage of cases develops evident stiffness, pain, and finger hindrance. Clinical presentation is negatively affected by eventual pathological fractures that may also be attributable to seemingly trivial activities such as moving or lifting light objects [1,9].
X-rays examination is mandatory to orientate differential diagnosis of the mass and make a presumptive diagnosis of chondroma, whether the image was taken after clinical suspicion or incidental. The typical radiographic aspect of enchondromas is a well-defined central lytic lesion involving diaphysis or metaphysis. Stippled calcifications and lobiuated contour of the mass as well as thinning, deformation and even disruption of the nearby cortices can also be visible. Periosteal reaction, extra-articular extension and soft tissue involvement are generally absent in hand enchondromas and their presence should make the physician suspect a malignant degeneration. Although definitive diagnosis can be made only after histological evaluation, X-rays alone generally represent a reliable diagnostic approach for the vast majority of cases [1,10].
Since enchondromas are slow-growing tumors with a low incidence of malignant degeneration [1,6,8-10], a surgical approach is recommended only for symptomatic patients and for in which imaging cannot exclude a malignant nature of the tumoral mass [9-11]. Although some authors suggest to delay surgery and immobilize the finger for 1 to 2 months in case of pathological fracture [10,12], while the vast majority of recentevidence proposes immediate one-stage intervention as the treatment of choice [6,12,13].
Surgery consists in curettage of the lesion. Depending on the individual case and the lines of reasoning of different institutions, curettage may be followed by the use of adjuvants like phenol, alcohol or CO_2 laser to eliminate residual nests of the tumor and theoretically decrease the risk of local recurrence [14-17]. Cryotherapy performed with liquid hydrogen has also been described with the same purpose [18]. Once the excisive part of the surgical treatment is complete, a subsequent reconstructive phase can be carried out. Several studies suggest the implant of bone chips as well as short unitary bone allografts or allografts to inhabit the void generated by removing the enchondroma in order to increase post-operative mechanical resistance [10,13-17]. Curettage represents a reliable and safe procedure to treat hand enchondromas, as testified by the low risk of major complication and local recurrence described in literature [6,7,17,19,20].
There is, however, a lack of evidence on the functional sphere. In fact, there is still a paucity of studies that focus on the impact hand enchondromas have on patients' activities of daily living before surgery. In parallel, little attention has been given to functional outcomes after surgical treatment, although hand performances is crucial to guarantee autonomy and independence to the individual.
In this paper we report our experience in surgical treatment of enchondromas of the hand, evaluating symptoms and natural history but also assessing upper limb functionality before and after surgery in order to understand the effects of the disease and its treatment on daily life of patients.

Materials and methods

This single-center retrospective study was approved by our local ethics committee and performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.
Our study consisted of a review of all patients who developed an enchondroma of the hand and were treated with curettage and bone grafting in our institution between September 2016 and September 2020.
For each patient we collected data regarding age, gender, first symptom associated with the disease and its date, alongside with the date of radiological diagnosis.
Pre-operative and post-operative functional status were evaluated using the QuickDASH score calculated at the moment of hospitalization before surgery and at last follow-up.
Frequency of sport activity involving the upper limb was assessed before and after surgery and was calculated on a monthly basis. We included in the calculation sports such as swimming, basketball, baseball, rowing or weightlifting, that require hand movements under resistance or presuppose continuous firm hold. Only sessions that lasted more than half an hour were taken into consideration.
Each patient underwent pre-operative X-rays and MRI scans (Fig. 1), which were used to orientate the diagnosis, guide surgical planning and estimate tumor size. Each neoplasm resected was examined by a pathologist to confirm the diagnosis of enchondroma.
Post-operative follow-up consisted of serial office visits, clinical evaluations and post-operative X-rays. Each complication with grade II or higher according to the Clavien – Dindo Classification was reported.

Surgical procedure

In the operative room patients were positioned on a radiolucent surgical table in supine position. A pneumatic tourniquet was set at the limb root and activated in case of necessity during the procedure. Surgical approach to metacarpal enchondromas was carried out through a dorsal incision, while protecting the extensor tendons and sagittal bands. Those involving proximal and middle phalanxes were approached with dorsolateral incisions, taking care to avoid damages to the central slip, lateral bands or local neuro-vascular bundles. For the distal phalanx a mid-lateral approach was preferred to the dorsal one in order to prevent injuries of the nail apparatus.
Once on the bone surface, linear osteotomies were practiced to shape a small window through the cortex. Curettage was then performed with Volkmann spoons and the removed mass

was preserved for histological examination. Margins were then extended with a high-speed burr. Recourse to local adjuvant therapy was considered on a case-by-case basis.
Bone allografts were used to induce osteointegration and provide better mechanical resistance and stability, with the aim to theoretically reduce the risk of post-operative fractures. The procedure was concluded by closing the cortical bone window with fibrin glue and finally suturing the surgical access.
X rays were taken after curettage to end the procedure.

Post-operative rehabilitation

Our post-operative protocol began with immobilization with a splint in intrinsic plus position for an average of 4 weeks. Patients were encouraged to keep their hands up and move actively and passively the articulations that were left free in order to minimize the tendency to hand edema. After the first 4 weeks the splint was removed and intense physiotherapeutic rehabilitation was started for the following 30 days. Each case was guided to practice daily active and passive mobilization of all the articulations of their hand with the aim to prevent or resolve disuse atrophy and stiffness after surgery and the subsequent immobilization. Periodical massages with elasticizing creams containing hyaluronic acid were done on the surgical site thereby reducing the risk of scar adhesions and restoring the appearance of the skin.
Light weight bearing was not allowed in any case until 30 days after surgery. Heavy weight bearing, sport practice and traumatic activities were allowed after 60 days or after radiographic signs of advanced bone consolidation.

Statistics

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

Results

21 patients underwent surgery to treat hand enchondromas in our institution between September 2016 and September 2020. There were 13 females and 8 males with a mean age at surgery of 38.8 (11-76) years. The tumor involved the metacarpal bone in 5 cases, proximal phalanx in 9, intermediate phalanx in 6 and distal phalanx in a single case. 11 of the 21 patients had chondroma in their fifth ray and 4 in their fourth ray, whereas the other 6 cases were affected at the first, second or third ray. Distribution is expressed graphically in Figure 2.
Diagnosis was incidental in 8 cases, while the remaining 13 were diagnosed with enchondroma due to the onset of at least one symptom. Pain (10 cases) was the most common presenting symptom for those whose clinical presentation preceded radiographic diagnosis. Before surgery, 5 cases did not have any pain, whereas the other 16 reported local pain. Among these latter, 4 patients had mild symptoms, 6 had moderate soreness and 6 described severe pain. Apart from cases who had incidental radiographic recognition of the tumor, diagnosis was established on average 3.5 (1-5) months after the onset of the first symptom. Diagnostic delay for enchondromas located in the fifth ray was significantly longer compared to those involving the other regions of the hand, according to an unpaired two-tailed t-test ($t = 2.392$; $p = 0.036$).

Figure 1. T1 MRI image of an enchondroma involving the distal segment of the 5th metatarsus.

Overall pre-operative upper limb functionality was assessed with the QuickDASH scoring scale, with a mean value of 35.2 (9.1-75.0). On average, before surgery, patients practiced sports involving the upper limb 2 (0-10) times per month.
An overview of patients' history, site involvement and clinical presentations is reported in detail in Table I.
All our cases were treated with tumor exposition, curettage and bone. None suffered from major complications during surgery or through the perioperative course.
The mean follow-up was 26.3 (57-9) months. At the latest office visit only 2 of our 21 cases developed local complications. Case 9 had persistent stiffness in his fourth finger and referred recurrent episodes of cramping pain, both treated with a combination of analgesics and physical therapy that reduced the magnitude and frequency. Case 17 developed a superficial in-

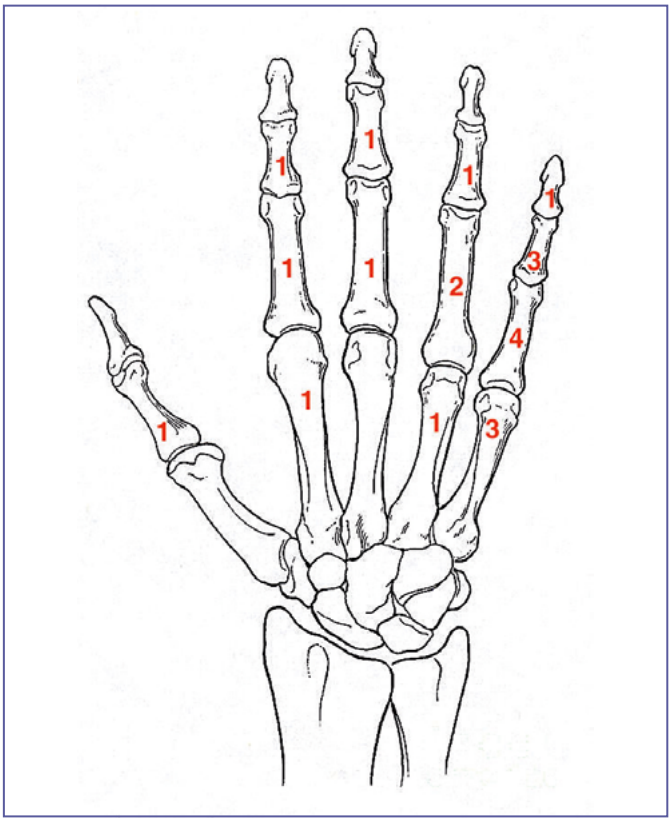

Figure 2. Distribution of enchondromas in hand bones.

fection that was successfully treated with oral antibiotic therapy. However, none had complications of grade III or higher according to the Clavien – Dindo Classification. The remaining 19 cases did not develop complications after surgery. Local recurrence was found in only one patient, case 12, who is now in our waiting list for further intervention.

Mean QuickDash score after surgery was 4.7 (0-22.7), a value 28.6 lower than that recorded before treatment. Two tailed paired t-test testified the difference between pre-operative and post-operative scores was statistically significant ($t = 4.426$; $p = 0.001$).

In fact, 18 of our 21 cases experienced increased lower limb functionality after surgical intervention. Articular range of motion of hand articulations were free and complete in 18 of the 21 cases in latest follow-up. In parallel to the increased performances, patients tended to practice sports more frequently, playing sports on average 2 (-4 - 10) times more each month. In fact, only the patient who had a local recurrence, case 12, was forced to reduce her sport activity. 4 cases did not change their training attitudes; among these 3 stated they did not train before or after surgery. The remaining 16 patients, the vast majority of our population, could increase the frequency of their sport practice. Increasement in training rate was statistically significant according to a two-tailed paired t-test ($t = 3.170$; $p = 0.005$).

Factors such as age, gender, diagnostic delay, presence of pain and other symptoms did not play a role as prognostic factors in our population.

Post-operative course and clinical outcomes are presented in Table II.

Discussion

Enchondromas of the hand are rare slow-growing tumors which involve the inner parts of the long bones of metacarpus and fingers. Made of cartilage-like tissue, they replace the native mature bone and often force the cortex to expand itself. Under the pressure of the neoplasm, involved bone segments tend to assume a shape similar to puffed rice, with subsequent reduced resistance to external stresses.

Despite their benign nature, enchondromas may cause pathologic fractures, pain and stiffness. These conditions may cause functional impairment, adversely affect patients' activities of daily living and even reduce individual autonomy. For this reason patients who develop disabling symptoms, as well as cases with radiological suspicion of malignant degeneration, should be treated with surgery [6,12,13].

In our population, in particular, pain was the most common presenting symptom. For symptomatic patients, time between the onset of the first sign and definitive diagnosis was on average 3.7 months and was significantly longer for cases who developed enchondromas in their 5th ray ($p = 0.036$). We suppose this statistical evidence is attributable to several factors. The 5th ray has a lateral position and ulnar dislocation of soft tissues can avoid increased local pressure due to bone growth. Furthermore, on the metacarpal region hypothenar eminence muscles may provide a soft pad that can reduce the risk of fracture and direct mechanical distress on the fifth metacarpal bone. Finally, the 5th finger is the one in which tensile forces are lower.

A surgical approach must be performed with a dual purpose: eradicate the enchondroma, minimizing the risk of local recurrence, and resolve the clinical picture for which it is responsable. In their review of 102 cases, Sassoon et al. [6] had a local recurrence rate of 7%. In 2002, Gaulke [7] examined an even larger population of 327 solitary enchondromas whose data were obtained by pooling his own patients with cases in literature, obtaining a recurrence rate of 14%. Sun et al. [9] did not report a single episode of local recurrence in their cohort of 20 cases. In our population only one patient had recurrent enchondroma, therefore the rate of local recurrence was 4.8%. This value, perfectly in line with those already present in literature, highlights the effectiveness of surgical curettage performed with high-speed burr to eradicate enchondromas in the hand [6,7,17,19,20]. Both our outcomes and evidence from the literature suggest curettage alone is sufficient to properly treat hand enchondromas, providing a good balance between clearance of the tumoral mass and distress of surrounding tissues. The use of cryotherapy and other local adjuvants like phenol, alcohol or

Table I. Pre-operative overview.

Case	Age (y)	Bone	Ray	Diagn. delay (m)	First sign	Pre-op pain	Pre-op QuickDASH	Pre-op sport (/m)
1	11	MC	2	0	(I)	NONE	59.1	2
2	20	MC	4	2	PAIN	SEVERE	47.7	0
3	22	MC	5	0	(I)	MILD	11.4	7
4	44	MC	5	5	PAIN	MODERATE	11.4	0
5	47	MC	5	3	PAIN	SEVERE	43.2	0
6	52	PP	1	3	PAIN	MODERATE	59.1	0
7	44	PP	2	0	(I)	NONE	18.2	0
8	52	PP	3	0	(I)	MILD	54.5	0
9	39	PP	4	3	PAIN	SEVERE	12.0	0
10	59	PP	4	0	(I)	SEVERE	43.2	0
11	54	PP	5	3	PAIN	MODERATE	27.0	0
12	34	PP	5	0	(I)	NONE	9.1	4
13	58	PP	5	5	PAIN	MODERATE	20.5	2
14	53	PP	5	0	(I)	MILD	59.1	10
15	12	IP	2	0	(I)	MILD	9.1	2
16	25	IP	3	1	PAIN	SEVERE	75.0	0
17	15	IP	4	5	FUNCT. LIMIT.	NONE	38.6	4
18	76	IP	5	5	FUNCT. LIMIT.	MODERATE	29.5	0
19	35	IP	5	5	SWELLING	NONE	15.9	4
20	24	IP	5	4	PAIN	MODERATE	31.8	5
21	39	DP	5	5	PAIN	SEVERE	50.0	0

(y): years; (m):month; (/m): per month; (I): Incidental diagnosis; MC: Metacarpus; PP: Proximal Phalanx; IP: Intermediate Phalanx; DP: Distal Phalanx; DIAGN. DELAY: Diagnostic Delay; FUNCT. LIMIT.: Functional Limitation.

CO_2 laser should be restricted to large enchondromas or cases with suspect malignant degeneration in + grade I chondrosarcoma. In such cases, the increased cellular mortality induced by the aforementioned treatments justifies the local damage to nearby healthy bone and soft tissues.

The literature defines curettage and bone grafting also as a procedure with low complication rates [6,7,17,19,20]. Sun et al. [9], in their series of 20 cases, reported a complication rate of 30%, but none of their patients required reinterventions (Clavien – Dindo classification II or lower). In our population, the rate was even lower, 4.8%, since only one case had post-operative complications. In their study, Sun et al. also showed that sex, age and location of the lesion do not represent reliable prognostic factors; our data are consistent with this observation.

In our experience, range of motion was completely restored and painless in 18 of 21 cases (85.7%), a percentage in line with literature data, between the 6.3% reported by Sollaci et al. [21] and the 30.9% by Sassoon et al. [6]. Good and painless hand motility is essential to restore hand functionality. Impairment represents one of the reasons for surgery in hand enchondromas and its complete resolution should be among the main focus in clinical practice. Nevertheless, as far as we know, to this date there is still a paucity of studies that evaluate post-operative functional status to assess the success of the intervention. We assessed pre-operative and post-operative upper limb functional status with the QuickDASH score, whtich showed a significant performance improvement after surgery ($p = 0.0001$). Better functionality allows patients to regain their independence and be able to come back to their previous activities of daily living. For most young active patients, in particular, sport represents a pivotal part of everyday routine and may play an important role in maintaining both physical and psychological health. For this reason, we paid attention to sporting activity, evaluating how many times per month patients practiced sport that actively involved the upper limb. Our data suggest that

Table II. Pre-operative overview.

Case	Age (y)	Bone	Ray	Compl.	Local recur.	Post-op QuickDASH	Post-op sport (/m)	Follow-up (m)
1	11	MC	2	NO	NO	0.0	12	57
2	20	MC	4	NO	NO	2.3	10	25
3	22	MC	5	NO	NO	0.0	7	32
4	44	MC	5	NO	NO	0.0	5	41
5	47	MC	5	NO	NO	4.5	7	18
6	52	PP	1	NO	NO	18.2	0	12
7	44	PP	2	NO	NO	4.5	2	9
8	52	PP	3	NO	NO	22.7	0	9
9	39	PP	4	YES	NO	12.0	1	13
10	59	PP	4	NO	NO	0.0	0	14
11	54	PP	5	NO	NO	0.0	4	19
12	34	PP	5	NO	YES	15.9	0	36
13	58	PP	5	NO	NO	0.0	4	18
14	53	PP	5	NO	NO	0.0	12	14
15	12	IP	2	NO	NO	0.0	4	39
16	25	IP	3	NO	NO	2.3	0	35
17	15	IP	4	YES	NO	13.6	5	20
18	76	IP	5	NO	NO	0.0	0	53
19	35	IP	5	NO	NO	2.3	8	40
20	24	IP	5	NO	NO	6.8	5	9
21	39	DP	5	NO	NO	0.0	4	39

(y): years; (m): month; (/m): per month; (I): Incidental diagnosis; MC: Metacarpus; PP: Proximal Phalanx; IP: Intermediate Phalanx; DP: Distal Phalanx; COMPL.: Complications; LOCAL RECUR.: Local Recurrence.

improvement in functional performances is associated with more frequent sport practice compared to pre-operative conditions. Although frequent physical activity could be easily seen as a consequence of good hand functionality, it is also true that the more patients actively use their wrist, palm and fingers, the quicker their performances will improve and the better they will get. Early intense rehabilitation, like that proposed to our patients, might be the key to enter this virtuous circle.

We acknowledge our study had some limitations. The rarity of these tumors did not allow us to operate on a larger population, which partially limited the statistical significance of some of the associations we wanted to investigate at the beginning of our research. Another limitation is represented by the retrospective nature of our study, which did not allow a perfect standardization of post-operative follow-up procedures for each patient.

In conclusion, curettage and bone grafting is a safe and effective procedure to treat hand enchondromas, with low rates of complications and local recurrences. In most cases, especially if surgery is performed properly by expert surgeons and early post-operative rehabilitation is allowed, surgery can also restore upper limb functionality. Increased performance encourages the return to previous activities of daily living and sport practice, increasing independence and quality of life.

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Conflict of interest statement

The Authors declare no conflict of interest.

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Authors' contributions

LA and EI: conceptualization; BS, EI and SDF: methodology,

validation and data curation; LA, EI and ADR: writing; RC: supervision and administration.

Ethical consideration

The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki.
The patients described in this case report signed an informed consent to participate to our research and the related article.

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