

## Hand enchondroma – complete evaluation and rehabilitation

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### Abstract

Enchondroma, the most frequently reported primary tumor in the long bones of the hand, is a common benign cartilaginous tumor, defined more exactly as a benign mature hyaline cartilaginous tumor that is located into the medullar space of the tubular bones. Between 2012 and 2018, we performed an observational study on six patients (two males and four females), aged 16 to 49 years old (mean 29.5 years), who were diagnosed during routine physical examinations with isolated enchondroma in their hand. The tumor was more frequently located in their proximal phalanges (four patients), while two patients had middle phalange tumors. The most common digit involved was the little finger (five patients), followed by the ring finger (one patient). The symptoms, which prompted surgical interventions, were: enlargement without fracture (two patients), pain or limitation of mobility (four patients), pain without pathological fracture (six patients). Studied patients were completely assessed before the treatment program (surgical intervention and rehabilitation program). The measured parameters and scales used were Visual Analogue Scale (VAS), Health Assessment Questionnaire (HAQ) scale for functional status and histological exam. For both VAS and HAQ, we observed a statistically significant difference between the initial and final evaluations, with  $p=0.03$  and  $p=0.035$ , respectively. Histological assessment and differential diagnosis are essential for the post-surgical treatment and rehabilitation program.

**Keywords:** enchondroma, hand, histology, rehabilitation.

### Introduction

The hand is not only a complex anatomic and bio-mechanic structure of the upper limb in the human body but also a place where varieties of benign (non-cancerous) tumors can be described. One type of musculoskeletal tumor of the hand is enchondroma, usually found in the tubular bones. After osteochondroma, is the following as frequency between benign bone tumors [1, 2].

Enchondroma is a common benign cartilaginous tumor, defined more exactly as a benign mature hyaline cartilaginous tumor located in the medullar space of the tubular bones. Fifty-four percent of enchondromas are described in the hand (more exactly, 35% of enchondromas arise in the hand) and the wrist, and the most frequent sites are metaphysis of the proximal (the most common site of occurrence) and middle phalanx, followed by the metacarpals. They can also be found in the distal phalanx [3–5]. Other possible tumor sites can be metacarpus, proximal, intermediate and distal phalanx, more frequently in the ulnar region.

Enchondromas are benign mature hyaline cartilaginous tumors that are usually solitary lesions in intramedullary bone, frequently located in the center of the bone (80%) [6].

They appear as cartilage islands that persist after the cessation of the endochondral ossification process in the

bone structure. Are commonly found in the bones of hands and feet, it can affect any bone structure and can occur at any age [7]. The evolution of the most common tumor of the phalanx of the hands is usually benign but has a tendency to relapse and is sometimes invasive, especially when developing in long bones [6].

Many are discovered accidentally on X-rays taken for other reasons; pain is the most common symptom of enchondroma [1, 2]. Patients of both genders or any race can be affected. The prevalence in males and females is equal. While it may affect an individual at any age, in general, enchondromas presents in adolescence or early adulthood. The age of diagnosis varies from 10 to 40 years old, with the mention that single-site enchondroma appears more frequently in patients between 20 and 30 years of age [8, 9]. Enchondromas may have single or multiple locations. Ollier disease is characterized by the appearance of the tumor with several localizations that can be found in bone structure of whatever size, often located on the same side of the body. Maffucci syndrome (when enchondromas are associated with soft tissue hemangiomas), occurs more frequently among males than females [4, 5, 7, 10, 11]. In these cases, the risk of malignancy increases by up to a quarter from unique localization patterns [10, 11].

The objectives of our study were to demonstrate the importance of correct clinical and histopathological (HP)

diagnosis in the management of the disease and to highlight the role of a complex post-surgical rehabilitation program on increasing functionality and pain reduction in patients with hand enchondroma.

### ☞ Patients, Materials and Methods

Between 2012 and 2018, we performed an observational study on six patients (two males and four females), aged 16 to 49 years old, who were diagnosed during routine physical examinations with isolated enchondroma of the hand.

Inclusion criteria for our study were represented by pain in the fingers, lab tests within normal limits and suggestive aspect for enchondroma without any sign of fracture. Exclusion criteria were pain in the fingers accompanied by any clinical and imagistic sign of trauma, hand swelling, increased local temperature or distal neurovascular deficit.

**Table 1 – Demographic patient data**

Statistic	Residence		Gender		Phalanx		Finger		Hand	
Category	Urban	Rural	Female	Male	Proximal	Middle	Finger 4	Finger 5	Right	Left
No. of cases	4	2	4	2	4	2	1	5	5	1
Percentage	66.67%	33.33%	66.67%	33.33%	66.67%	33.33%	16.67%	83.33%	83.33%	16.67%

The study was conducted after prior written consent was obtained from all patients and approval was received from the Ethics Committee of the Hospital.

Studied patients were completely assessed before treatment program (surgical intervention and rehabilitation program). Measured parameters and used scales were:

- pain: Visual Analogue Scale (VAS);
- functional status: Health Assessment Questionnaire (HAQ) scale.

Biopsy samples were collected intraoperatively and sent for HP examination. All tissue fragments were carefully analyzed by optical microscopy because the histological appearance of cartilaginous and bone tissue may vary from one area to another. Histological exam of hand tumor was performed using usual stainings – Goldner–Szekely (GS) trichrome and Periodic Acid–Schiff (PAS)–Hematoxylin–Eosin (HE) methods. In order to assess if the tumor had any malignancy sign, we also used immunohistochemical (IHC) techniques that show cell proliferation and tumor differentiation – proliferating cell nuclear antigen (PCNA), p53 and Ki67.

After surgical treatment, we evaluated postoperative clinical range of motion, functional status with the HAQ scale and frequency of complications or recurrences. The average follow-up duration was 17 months, ranging from 10 months to 24 months. All patients were compliant with the rehabilitation program after surgical intervention.

The rehabilitation program included massage of upper limb, adapted finger exercises (static exercises were started on second day after surgery, then, gentle mobilizations of all the upper limb joints, muscle strengthening exercises, unconstrained and constrained exercises) and activities of daily living (ADL) exercises. We recommended a home-training program – few simple hand exercises for all joints in the hand fingers, as it is mentioned in medical data. Partial weight bearing in operated hand was allowed after six weeks.

Imagistic evaluation included only plain radiography because is the first-intention investigation, non-invasive with suggestive aspect for diagnosis. The other imagistic investigations, magnetic resonance imaging (MRI) scan or computed tomography (CT) scan were not performed in our studied patients because the medical team considered that plain radiographs are enough for the correct diagnosis, in accordance with clinical and functional patient status.

All patients underwent surgical treatment from 2014 to 2016, because all of them presented abnormal growth and atypical radiological findings. None of our patients had finger fractures. The operative methods used were tumor resection and thorough curettage of the lesion and the use of bone autograft from iliac bone to fill the defect in the zone of resection, and they were operated on by the same surgeon.

The patients' demographics are listed in Table 1.

### Statistical analysis

Data was expressed as mean  $\pm$  standard deviation (SD). Because there were only a few patients and the data distribution could not be confirmed to be Gaussian, we used the non-parametric Wilcoxon test for paired data.

### ☞ Results

Our investigation focused on patients with hand enchondroma, the most common type of non-cancerous bone tumor, originating from cartilage (the specialized, gristly connective tissue from which most bones develop), that lines the inside of the bones of the hands.

### Clinical and imagistic assessment

In our study, we included a number of six patients. Four were women and two were men. Clinical evaluation leads to a preliminary diagnosis – an isolated tumor, probably enchondroma, in the patient's right hand – five patients, and in the left hand – one patient. The tumor was more frequently located in their proximal phalanges – five patients and for two patients it was located in their middle phalanges. The most common digit involved was the little finger (five patients), followed by the ring finger (one patient). The symptoms, which lead to the decision for surgical treatment, were: enlargement without fracture (two patients), pain or limitation of mobility (four patients), pain without pathological fracture (six patients). All patients were non-smokers.

Hand radiographs showed a central circumscribed lesion with osteolytic appearance in the meta-diaphysis of the phalanx, with a small amount of calcified matrix. The structure of the bone cortex seems not to be affected but may appear thinner. No soft tissue extension is observed. Taking into consideration the Takigawa classification (location of the tumor: central, eccentric, combined, polycentric or giant features) of the radiographic images

of enchondroma, five of the patients included had a central location of the tumor, while only one presented an eccentric localization (Figure 1).



**Figure 1** – Antero-posterior left-hand X-ray showing the characteristic image of a distal phalanx enchondroma in the ulnar finger, proximal phalanx. The well-delimited, radiolucent lesion is seen, which widens and thickens the antero-posterior diameter of the cortices.

**Table 2** – Parameter values in studied patients

Statistic	Age [years]	VAS1	VAS2	HAQ1	HAQ2	Follow-up [months]
No. of observations	6	6	6	6	6	6
Mean	29.5	8.33	1.67	16.33	10.5	17
Standard deviation	14.08	0.82	0.52	1.21	1.05	5.48
Minimum	16	7	1	15	9	10
1 <sup>st</sup> Quartile	19.5	8	1.25	15.25	10	13
Median	24	8.5	2	16.5	10.5	17
3 <sup>rd</sup> Quartile	40.5	9	2	17	11	21
Maximum	49	9	2	18	12	24
<i>p</i> Wilcoxon	–	0.03 < 0.05 – S		0.035 < 0.05 – S		–

VAS: Visual Analogue Scale; HAQ: Health Assessment Questionnaire; S: Statistically significant.

### Histological assessment

Figures 2–5 illustrate the histological characteristics of enchondromas in our studied patients. Microscopic examination showed cartilaginous nodules coated with bone tissue, lobules of mature cartilage containing lacunae separated by fibroconnective stroma, intra- and parabolular calcification and ossification. We observed as well that the chondrocytes within the lobules had different shapes, some had small hyperchromic nuclei, but some of them had no nuclei. On many of the images, the cartilaginous lobules were surrounded by bone tissue, but we also noticed in a few images a demarcation line between the two types of tissue. Immunoassay with PCNA, p53 and Ki67 antibodies was negative in all six patients, showing the benign character of the tumor.

### Discussions

Enchondroma is frequently found in long bones metaphysis. The bone cortex may appear thin, but usually remains intact. A cortical defect rarely appears, when tumor

### Functional assessment

In the end of the rehabilitation program, no further treatment was required. No complications or relapses were reported. Our patients gained full range of motion of fingers and optimal hand function, with radiological evidence of bone incorporation.

At four to six months follow up, all patients were able to bear complete weight, and were able to perform optimally the activities of daily living.

In Table 2, we are presenting the mean and SD of the VAS and HAQ scores for the studied patients and the correlation between pre-operative and post-operative values. For both VAS and HAQ scales, we observed a statistically significant difference between the initial and final evaluations, with  $p=0.03$  and  $p=0.035$ , respectively.

The parameter “pain” was appreciated with the VAS, which all patients completed at two moments: T1 – pre-operative and T2 – post-surgical intervention and after the rehabilitation program. The average value of the VAS for the entire group improved. In the beginning, the average value of the VAS score 8.33 (SD: 0.82) and at the end of the evaluation the VAS score 1.67 (SD: 0.52).

The global functional status estimated with the help of HAQ questionnaire was improved. The pre-operative average value was 16.33 (SD: 1.21), and four months later, the average score had an average value 10.5 (SD: 1.05) (Table 2).

expands through the cortex, and defined enchondroma protuberans [12, 13]. The histological origin of an enchondroma is a change that occurs in cartilage tissue structure, which is manifested by its reorganization as columns that remain uncalcified, which are surrounded by bone tissue [3]. The neoplastic chondrocytes of enchondroma are found within a hyaline or myxoid tissue. The tumoral cells present a pseudo-lobular distribution, with calcifying areas inside. Cell mitosis and alterations that may occur in the structure of the cell nuclei are rare [14].

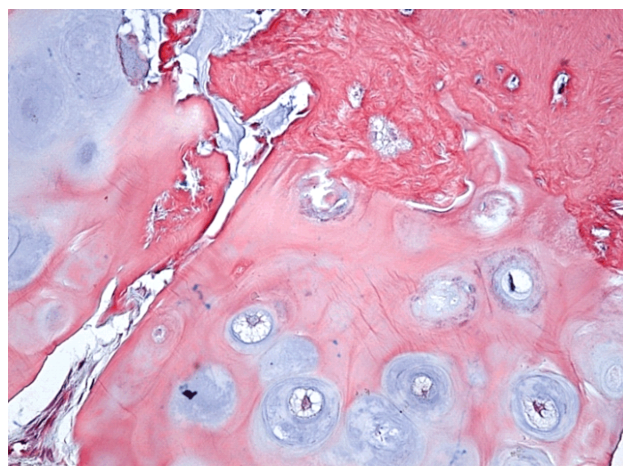
Normally, the tumor does not expose to the bone cortex, rarely encounters protruding forms [15]. Malignant transformation of solitary enchondromas of the hand into a chondrosarcoma is rare and is associated with a very low rate of metastatic dissemination [16].

Enchondromas are generally asymptomatic [17]. Patients with enchondromas usually have few signs and symptoms (typically a localized painless swelling). Sometimes, an enchondroma may present itself with local pain (the pain experience in some patients is possible if the tumor

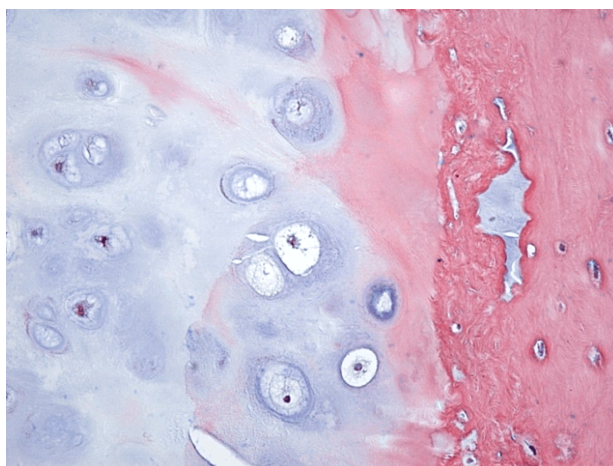


becomes very large or causes abnormal growth of the affected area or, and if the tumor affects the quality of the bone tissue, with possible fractures on the pathological

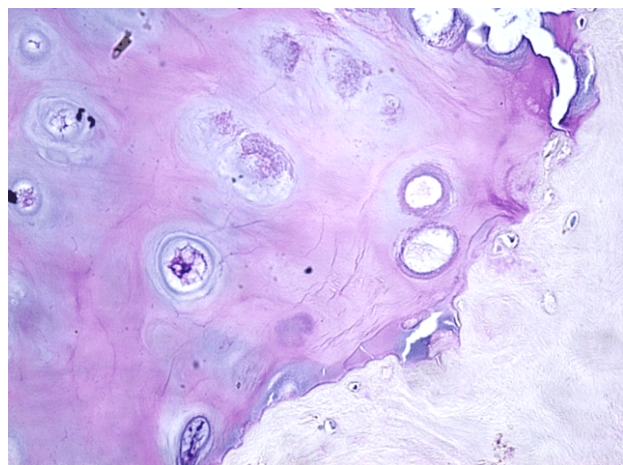
bone caused by minor trauma, or diagnosed during a routine physical examination, as an accidental discovery on plain radiographs [3, 17, 18].



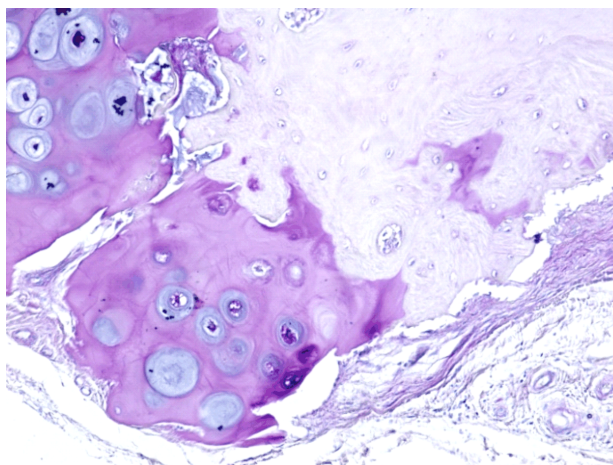
**Figure 2** – Bone tissue is observed crossing the cartilage lobules. Chondrocytes with different sizes, some with hyperchromic nuclei, some cells without any nuclei (GS trichrome staining,  $\times 200$ ).



**Figure 3** – The boundary between bone tissue and cartilaginous lobules. It can be observed the cellular polymorphism (GS trichrome staining,  $\times 200$ ).



**Figure 4** – Deposition of bone at the edges of the hyaline cartilage lobule (PAS-HE staining,  $\times 200$ ).



**Figure 5** – Calcification around the pseudo-lobular arranged chondrocytes. Some of the nuclei are small and round with condensed chromatin (PAS-HE staining,  $\times 200$ ).

The therapeutic approach should take into consideration aspects related to pre-existing health status of the patient as well as aspects related to the disease. Usually, the non-surgical treatment with radiological follow-up examinations is suggested for small (<3 cm), asymptomatic, incidentally found tumors, without qualitative or quantitative changes in bone tissue or changes in the shape and size of the tumor [7, 18, 19]. The rate of relapse is low and, if it occurs, is at a very slow pace being directly related to the accuracy of tissue removal during primary surgery [20].

We analyzed the evolution of patients diagnosed with hand enchondroma without fractures (clinical, functional, imagistic, histological and IHC assessment), and realized a follow-up of the hand disability after rehabilitation program, recommended after surgical intervention.

We found only a few other similar studies in the medical literature concerning the functionality and pain management in patients with hand enchondroma. We

assessed the functional status in our study group using the HAQ scale in contrast with other studies, where other scales were used and patients with enchondroma suffered fractures before the surgical treatment, and VAS scale that is the most widely used scale for pain assessment in patients with musculoskeletal disorders [5, 21]. In the medical literature, a large group of studies was published about various treatment options for enchondroma [18, 19, 22–25].

Traditionally, enchondroma is treated with curettage and grafting with allogeneic bone or autogenous or synthetic bone substitutes. There is no absolute agreement on what the best surgical technique should be used for this type of tumor. There is no consensus regarding the need to use bone grafts after curettage or if their use has any impact on the subsequent evolution of the condition [17, 26–28].

Therapy should be customized as appropriate. In early stages, for a small lesion, a simple curettage is usually enough. For larger lesions, the gap left in the bone

structure requires the use of bone grafts taken from the iliac crest or from the distal end, this technique is being widely used nowadays [29, 30].

In our patients, we first applied conservative treatment through regular check-up, similar to other studies, and then surgical excision using tumor curettage and reconstruction of the bone defect with a block of bone autograft. This surgical attitude followed by rehabilitation program with good functional outcomes proved to be the optimal management of this type of patient [31–33].

We preferred to use autograft, because it gives adequate osteogenesis, osteoinduction and osteoconduction to the procedure; moreover, it is proved that this type of bone reconstruction is rapidly incorporated, with an average consolidation time of seven weeks, and patients are able to come back to their day-to-day activities [34].

Enchondroma usually occurs in the first through fourth decade of life. Today, it has a wide age range from 5 to 80 years old [35]. The epidemiology of the present study differs from the reported literature: our patients were younger than outlined in the literature (the mean age of 28.7 years in some studies), with a slight female predominance, like in other studies [33, 36].

This type of tumor often affects the small bones from the ulnar region of the hand. Moreover, the location of enchondroma is the same as described worldwide, proximal phalanges were the most frequently affected regions, followed by middle phalanges. Probably, our patients had no fractures when they were initially diagnosed because the bone has not been weakened enough by the disease process and they had a preventive attitude for minor hand trauma, which might otherwise cause a fracture in healthy bone [37–39].

Almost all tumors in our study are located centrally, with a predilection for the proximal phalanx, generally asymptomatic, described on X-rays as a circumscribed lucent lesion found in the diaphysis of the small bones of the hand similarly to other studies [1, 40, 41].

All patients included in our study were non-smokers. We consider smoking a real risk factor for bone pathology, so the non-smoker status is very important for community health [42].

In all our patients, the diagnosis was formulated after corroborating the clinical and imagistic findings, intra-operative aspect of the tumor, as well as the histological appearance, excluding diagnosis such as osteoarthritis, gout or rheumatoid arthritis [43]. There was no mismatch between radiological and histological diagnosis. Radiographs typically demonstrated a well-defined lytic lesion, central or eccentric, habitually containing calcified chondroid matrix non-invading in the surrounding tissue. Additional diagnostic imaging for enchondroma may include radio-nuclide bone scan, MRI and CT scan, but in our cases, plain radiographs are sufficient for the diagnosis.

Enchondroma accounts for 10–25% of all benign tumors. These tumors are poorly vascularized, with low cellularity, and are rich in hyaline cartilaginous tissue and can present myxoid degeneration. Enchondromas are well delimited from the surrounding tissues, such as trabecular bone or bone marrow. The structure of surrounding bone tissue advocates the benign aspect of the condition, which is easily visualized at higher magnification [35].

Cartilaginous cells may have small, round shaped nuclei, rich in chromatin. Some of the cells may have two nuclei without their appearance undergoing any changes. Mitotic activity could not be emphasized. Endosteal erosion can be observed occasionally, as well as myxoid matrix. Bone tissue surrounding the edges of the cartilaginous lobules is a normal finding, while entrapment of preexisting host bone is not found usually and should be regarded as a sign of malignancy [35].

On classical histological samples, obtained through staining methods that demonstrated their utility in other studies concerning bone and cartilaginous tissue diseases [44, 45], we noticed the presence of a demarcation line between the bone tissue and the cartilaginous tissue. Bone tissue was also observed crossing the cartilage lobules. Chondrocytes of different sizes, some with hyperchromic nuclei, some without any nuclei were seen in all of our patients. Pseudo-lobular arranged chondrocytes were seen, as well as changes in the cellular structure as some of the nuclei of the chondrocytes were small and round with condensed chromatin.

The structure of enchondroma usually is organized in cartilaginous lobules of variable sizes and shapes. Cellularity depends on the age of the patient, the location of the tumor but also within the same tumor from the central area to the periphery area. The tumors located in the long bones of the hands and feet tend to be rich in cellularity with a cellular pleomorphism, chondrocytes that present two nuclei of even shapes and sizes [5].

In younger patients hands and feet small bones, in which the ossification process did not end, even more troubling histological aspects that are usually found in malignant tumoral tissue, such as abundant myxoid matrix, rich cellularity, cytological atypia or nuclear hyperchromasia are tolerated [35].

Typically, the histological aspect is relevant, but in special cases, immunohistochemistry techniques can be used, such as the use of S100 antibody, to which chondrocytes exhibit a positive reaction. Patients in our study had PCNA, p53 and Ki67 antibodies negative reaction, showing the benign character the tumor. Some data has reported on its morphology and this aspect is important to make the differential diagnosis of enchondroma from other tumors, like chondrosarcomas, epidermoid cyst and glomus [46, 47].

If enchondroma is a chondroid tumor with a slow growth pattern and a regular lobulation structure, with almost inactive fibrous capsule (with little blood vessels and low cellularity), chondrosarcoma is a tumor with fast growth and an asymmetrical, irregular lobulation pattern, with capsule containing blood vessels and numerous active blast cells [46]. In some studies, five histological distinctive features for chondrosarcoma are mentioned: production of malignant cartilage, medullary cavity infiltration, osseous trabeculae entrapment, Haversian systems infiltration, and normal bone destruction [48]. Moreover, two years ago, insulin-like growth factor II mRNA-binding protein (IMP3) was defined as a novel marker for differentiating problematic cases of enchondroma from well-differentiated chondrosarcomas [35].

Epidermoid cysts and glomus are two entities frequently described in distal phalanx, and the clinical data is different than enchondroma. Imagistic and histological

findings make the distinction for these tumors [5]. The risk of malignant transformation into chondrosarcoma is 1%, and recurrence is 2–15% [34]. The causes for malignant transformation are still unknown, but there have been attempts to identify them with cytogenetic studies. The possibility of relapse after surgical treatment is 2% to 15%. However, recurrence does not seem to affect healing rates and the post-operative range of motion [7, 17, 49, 50].

## ✉ Conclusions

Patients with hand enchondroma must be fully evaluated to established optimal management. Histological assessment and differential diagnosis are essential for post-surgical treatment and rehabilitation program. Surgical intervention before the onset of local complications and the establishment of a complex post-surgical rehabilitation program improve both functional status and pain relief in these patients.

## Conflict of interests

The authors declare that they have no conflict of interests.

## Authors' contribution

Magdalena Rodica Trăistaru and Otilia Constantina Rogoveanu equally contributed to this article.

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