—Original—

Bone Changes Associated with Soft-tissue Tumors of the Hand

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Abstract

The purpose of this study was to clarify clinical and radiographic features of bone changes associated with soft-tissue tumors of the hand. We reviewed clinical records and radiographs of 115 patients who had undergone operations for soft-tissue tumors or tumorous conditions of the hand. Bone changes were detected in the radiographs of 21 of the 115 patients. Giant cell tumor of tendon sheath was the most common histological type to be associated with bone changes. The most vulnerable part of the hand was the palmar side of the phalanx from the distal shaft to the head. Most of the bone changes were erosion with clear margins. The erosions tended to extend deeper into the bone with limited widening. "Steep deep" erosions were found in 5 patients; these erosions did not require reconstruction after surgical curettage, and tumors did not recur.
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Key words: bone, erosion, soft-tissue tumor, hand surgery

Introduction

Benign but bothersome soft-tissue tumors, such as giant cell tumor of tendon sheath (GCTTS), commonly occur in the hand, although malignant tumors rarely occur[1,2]. Bone changes are sometimes found upon X-ray examination of soft-tissue tumors of the hand[1,3,4]. In many cases, the bone changes are pressure erosions with a gentle slope[1]. However, in a few cases, the pressure erosion is deep with a steep slope, which can complicate diagnosis and treatment[3,4]. Such a deep erosion with a steep slope can mimic a bone tumor and may require meticulous curettage and further treatment, such as bone grafting[3,4]. However, bone changes associated with soft-tissue tumors of the hand have not been thoroughly studied to date. Numerous issues have not been clarified. How frequently are bone changes associated with soft-tissue tumors? What soft-tissue tumors tend to be associated with bone changes? What parts of the hand are vulnerable to bone changes? What types of bone changes are common? How do bone changes progress? For a clinician to treat tumors of the hand, it is important to obtain comprehensive information on bone changes. The purpose of this study was to clarify clinical and radiographic features of bone changes associated with soft-tissue tumors of the hand.

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Materials and Methods

Data were reviewed of all patients who had undergone an operation for a soft-tissue tumor or a tumorous condition of the hand at Nippon Medical School Hospital from January 1993 through November 2006 or at Tama Nagayama Hospital, Nippon Medical School from September 2005 through November 2006. Patients with recurrence, palmar fibromatosis, or synovitis were excluded. Twelve patients were also excluded because preoperative radiographs were not available. A patient with an epidermoid cyst involving the distal phalanx was excluded because the distal phalanx might have been modified by an old open fracture injury. Finally, 115 patients (66 women and 49 men; mean age, 44 years) were included in this study. Clinical information was retrieved from clinical records. Anteroposterior and lateral radiographs were obtained and evaluated for all lesions.

The frequency of bone changes was determined by studying preoperative radiographs of each patient. Histological diagnoses and locations of lesions were also investigated. When a lesion was large, its location was determined from its center. The relationship of the presence of bone changes to lesion size (maximum diameter) was investigated. The relationship of the presence of bone changes to the interval from the initial awareness of a lesion to the first consultation was also investigated. When a lesion had multiple separate tumors, such as in synovial chondromatosis, its size was determined from that of the largest tumor. Data on size and interval were available for 114 and 112 patients, respectively. These relationships were analyzed with the Mann-Whitney U test.

Preoperative radiographs were also assessed to determine the characteristics of bone changes. The characteristics included depth and steepness of erosion. The depth was defined as the distance from the estimated surface of the cortex to the deepest point **(Fig. 1)**. The steepness was defined as the ratio of the depth to the length of the base of erosion **(Fig. 1)**. When erosion was seen on both anteroposterior and lateral views, the deeper erosion was used. When a secondary erosion was upon a basic erosion **(Fig. 2)**, the deeper erosion was used. When erosions were found on multiple bones, the deepest erosion was used. We defined "steep deep" erosions as those having both a depth of 3 mm or more and a steepness of 50% or more.

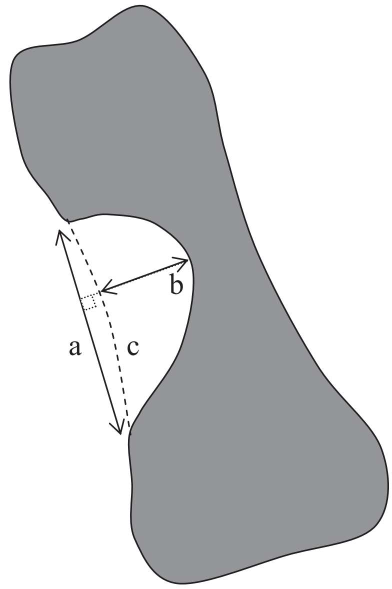

Fig. 1 Depth and steepness (ratio of depth to base length) of bone erosion. a: Base, b: depth, c: estimated bone contour.

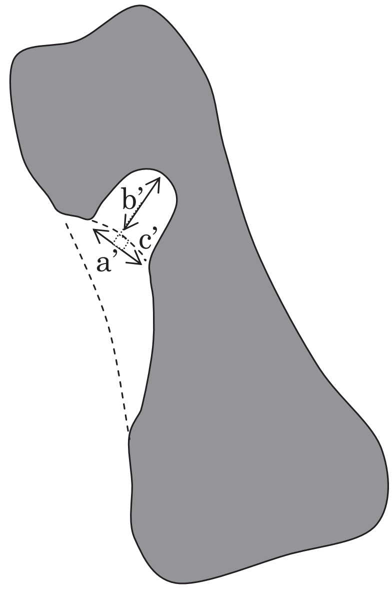

Fig. 2 Depth and steepness (ratio of depth to base length) of secondary erosion on the basic erosion. a': Base, b': depth, c': estimated contour of basic erosion.

Table 1 Frequencies of bone changes determined by histological diagnosis

Histological type	No. of patients	No. of patients with bone changes
Giant cell tumor of tendon sheath	32	14
Ganglion cyst and mucous cyst	13	0
Hemangioma	12	1
Lipoma	11	1
Epidermoid cyst	8	0
Schwannoma	4	1
Glomus tumor	6	2
Fibroma of tendon sheath	3	0
Synovial chondromatosis	4	2
Others[a]	22	0
Total	115	21 (18%)

[a]: Epithelioid sarcoma, squamous cell carcinoma, dermatofibrosarcoma protuberance, soft tissue chondroma, fibrous histiocytoma, neurofibroma, angioleiomyoma, intravascular papillary endothelial hyperplasia, hematoma, trichilemmal cyst, cellular blue nevus, and clear cell hidradenoma.

Table 2 Frequencies of bone changes in terms of location

Site	No. of patients	No. of patients with bone changes
Thumb	13	1
Index finger	22	8
Middle finger	23	7
Ring finger	7	3
Little finger	9	2
Distal palm of midpalm	19	0
Palmar web of thumb	3	0
Thenar	8	0
Hypothenar	5	0
Hand dorsum	6	0
Total	115	21 (18%)

Results

The histological diagnoses of all 115 lesions are summarized in **Table 1**, and the locations are summarized in **Table 2**. The most common diagnoses were GCTTS and ganglion cyst (mucous cyst). Only 2 malignant lesions (epithelioid sarcomas) were included. The fingers, particularly the index and middle fingers, were the most common lesion sites.

Bone changes were detected in radiographs of 21 (18%) of the 115 patients (**Table 1**). GCTTSs accounted for two-thirds of all lesions with bone changes; nearly half of GCTTS lesions were associated with bone changes (**Table 1**). Many other types of tumor were also associated with bone changes, although not as frequently as GCTTS (**Table 1**). Bone changes were common in the fingers but were not observed on the palm or dorsum of the hand (**Table 2**).

The clinical and histological data of patients with bone changes are summarized in **Table 3**. The original sites of the lesions were usually the tendon sheath or the joint capsule. Lesions with bone changes (n=21; median size, 19 mm) were significantly larger ($p<0.05$) than lesions without bone changes (n=93; median size, 13 mm). The interval from initial awareness of a lesion to first consultation did not differ between lesions with bone

Table 3 Summary of clinical and histological data of patients with bone changes

Patient no.	Age	Sex	Location	Original site	Histology	Maximum diameter (cm)	Duration[a] (months)
1	70	F	Thumb	TS	GCTTS	1.5	11
2	54	F	Middle f.	TS	GCTTS	1.6	2
3	39	M	Index f.	DIP joint	GCTTS	2.9	48
4	11	M	Middle f.	TS	GCTTS	1.5	6
5	27	F	Little f.	DIP joint	GCTTS	1.5	12
6	5	F	Middle f.	TS	GCTTS	1.5	12
7	16	M	Index f.	TS	GCTTS	2	1
8	21	F	Index f.	TS	GCTTS	2.5	24
9	24	F	Index f.	PIP joint	GCTTS	2.9	48
10	42	M	Index f.	PIP joint	GCTTS	2.9	12
11	63	F	Little f.	DIP joint	GCTTS	1.9	60
12	34	F	Index f.	TS	GCTTS	1.8	6
13	31	M	Index f.	PIP joint	GCTTS	2.2	2
14	51	M	Middle f.	DIP joint	GCTTS	3	16
15	65	F	Middle f.	Subcutis	GT	0.8	240
16	27	F	Ring f.	Subcutis	GT	0.9	48
17	54	M	Ring f.	DIP joint	SC	0.8	36
18	64	F	Middle f.	DIP joint	SC	1.3 & 0.7	15
19	53	F	Middle f.	Subcutis	Heman.	2	36
20	38	M	Index f.	Subcutis	Lipoma	3.5	216
21	44	M	Ring f.	Subcutis	Schwan.	1.5	36
						1.8[b]	16[b]

[a]: Duration from initial awareness of lesion to first consultation, [b]: median, TS: tendon sheath, GCTTS: Giant cell tumor of tendon sheath, f.: finger, GT: Glomus tumor, SC: Synovial chondromatosis, Heman: Hemangioma, Schwan: Schwannoma, FTS: Fibroma of tendon sheath

changes (n=21; median interval, 16 months) and those without bone changes (n=91; median interval, 12 months).

The characteristics of bone changes are summarized in **Table 4**. Almost all bone changes were erosion with clear margins. Only 1 lesion, a hemangioma, was associated with only sclerotic changes of the cortex of the middle phalanx shaft without erosion. Two lesions with synovial chondromatosis of the distal interphalangeal joints were associated with bone erosions in 2 phalanges, the distal and middle phalanges. In these patients, the erosions of the distal phalanges were larger than those of the middle phalanges. The radiographs of GCTTS lesions showed a secondary erosion on a basic erosion in 2 patients (**Fig. 3**). No ill-defined erosions or periosteal reactions were found. The palmar side of the phalanx from the distal shaft to the head was the most commonly affected site.

The median depth of the erosions was 1.8 mm (range, 0.3–4.8 mm), the median base length was 7.0 mm (range, 3.2–12.7 mm), and the median steepness was 28% (range, 4%–110%). The erosions tended to increase in depth without increasing in base length (**Fig. 4**). “Steep deep” erosions were found in 5 patients; these erosions were on the palmar side of the head of the phalanx in 3 patients with GCTTS (**Fig. 3**), on the palmar side of the distal shaft of the distal phalanx in 1 patient with lipoma, and on the lateral side of the distal shaft of the middle phalanx in 1 patient with schwannoma. The median depth and steepness of these erosions were 3.6 mm (range, 3.1–4.8 mm) and 67% (range, 54%–110%), respectively. During surgery for these “steep deep” erosions, no reconstruction of the phalanges was required after meticulous curettage of the erosions. These lesions have not recurred after a mean follow-up period of 36 months (range, 1–94 months).

Discussion

The present results show that soft-tissue tumors

Table 4 Summary of characteristics of bone changes

Patient no.	Bone change	Affected bone	Affected site in phalanx	Palmar, dorsal or lateral ?	Depth (mm)	Base (mm)	Steepness (depth/base)
1	Erosion	Proximal p.	Distal shaft	Palmar	1.7	12.1	14%
2[a]	Erosion	Middle p.	Head	Palmar	1.2	7	17%
					3.1[b]	4.6[b]	67%[b]
3	Erosion	Middle p.	Distal shaft	Palmar	2.8	7.8	36%
4	Erosion	Proximal p.	Distal shaft	Palmar	0.6	7.8	8%
5	Erosion	Middle p.	Shaft	Dorsal	0.5	3.7	14%
6	Erosion	Proximal p.	Distal shaft	Palmar	1.7	6	28%
7[a]	Erosion	Proximal p.	Head	Palmar	4.8	7	69%
8	Erosion	Proximal p.	Distal shaft	Palmar	0.3	7.1	4%
9	Erosion	Proximal p.	Head	Palmar	2.8	3.2	88%
10	Erosion	Proximal p.	Distal shaft	Palmar	1.6	11.7	14%
11	Erosion	Middle p.	Shaft	Whole	1.2	7	17%
12	Erosion	Middle p.	Distal shaft	Palmar	1.8	6.1	30%
13	Erosion	Proximal p.	Distal shaft	Palmar	0.7	9.6	7%
14[a]	Erosion	Middle p.	Head	Palmar	3.6	12.7	28%
					3.5[b]	4.5[b]	78%[b]
15	Erosion	Distal p.	Distal shaft	Palmar	0.3	4.6	7%
16	Erosion	Distal p.	Distal shaft	Lateral	2	9.1	22%
17	Erosion	Distal p. (Middle p.)	Base (Head)	Palmar (Lateral)	2.2	6.7	33%
18	Erosion	Distal p. (Middle p.)	Base (Distal shaft)	Palmar (Palmar)	1.8	3.6	50%
19	Sclerosis	Middle p.	Shaft	Lateral	—	—	—
20[a]	Erosion	Distal p.	Distal shaft	Palmar	3.6	3.3	110%
21[a]	Erosion	Middle p.	Distal shaft	Lateral	3.7	6.9	54%
					1.8[c]	7.0[c]	28%[c]

[a]: Patients with a steep deep erosion, [b]: Secondary erosion on basic erosion, [c]: median, p.: phalanx

Fig. 3 Lateral view of radiograph of patient 14 (giant cell tumor of tendon sheath). A secondary erosion **(arrow)** on the basic erosion **(arrow heads)** was observed on the palmar side of the head of the middle phalanx. This erosion meets the criteria for a "steep deep" erosion.

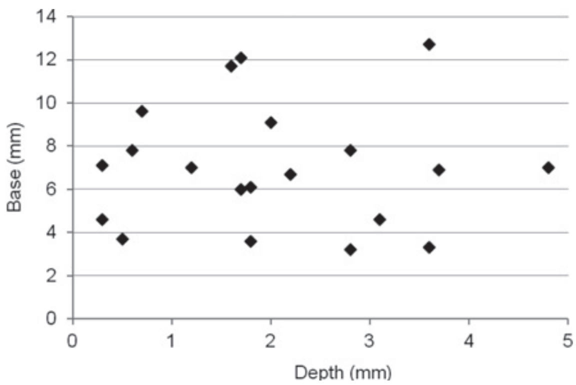

Fig. 4 The depth tended to increase without an increase in base length.

of fingers are often associated with bone erosion. The reason for this association may be that a lesion has a limited space to expand in the finger[5]. Another reason may be that GCTTS is a common tumor of the finger. The frequency of bone erosion associated with GCTTS has been reported to be high (8%–39%)[4,6,7], as it was in the present study.

This tumor usually originates from soft-tissue structures that are directly connected to the bone, such as the tenosynovium and the joint synovium[8], which may be why GCTTS frequently causes bone erosion.

Various mechanisms underlying bone erosion associated with GCTTS have been reported. Fletcher, et al.[9] have stated that a high frequency of limited bone erosion supports the view that an occasional case of extensive bone involvement is also a case of erosion rather than a case of a true invasive growth. They have also stated that if a tumor is firmly bound down by ligaments or tendons, it is more likely to cause erosion of the cortex and to expand within the marrow cavity. McMaster[10] have observed that this type of tumor extends directly through the articular cartilage and the cortex at the chondro-osseous junction of the knee joint. Scot[11] has speculated that this type of tumor invades the bone through the vascular foramina underlying the diseased synovium in large joints. More recently, Uriburu, et al.[4] have reported several tumors that invaded the bone by directly penetrating the cortex.

The present study has found that the most vulnerable part of the hand is the palmar side of the phalanx from the distal shaft to the head. A tumor here can be firmly bound down by the flexor tendons and can involve the chondro-osseous junction and the vascular foramina underlying the diseased synovium. The vulnerability of this part can be related to the 3 mechanisms mentioned above. The vulnerability of this part might also be related to the pressure of the palmar proximal edge of the distal (middle) phalanx and the palmar plate when the distal interphalangeal joint (proximal interphalangeal joint) flexes.

The present study has revealed a correlation between lesion size and the presence or absence of bone changes. This correlation is reasonable because a larger lesion exerts greater pressure on the bone both at rest and during movement of the adjacent joint. The present study also found no significant difference in the interval from the initial awareness of a lesion to the first consultation between lesions with bone changes and those without bone changes. This lack of difference in the interval might be due to the variation in growth rates among individual lesions and the interval not being directly related to pressure on the bone.

The present study also found that erosions tended to increase in depth without increasing in base length. This finding suggests how erosion progresses; the erosion extends deeper into the bone with limited widening. This process may explain the presence of "steep deep" erosions.

There have been several reports of lesions similar to the "steep deep" erosion. De Schepper et al.[3] have reported 6 GCTTSs with intrinsic osseous lesions among a series of 200 consecutive osseous (pseudo) tumors of the hand. Uriburu, et al.[4] have reported 15 GCTTSs with cortical perforation and intraosseous expansion which accounted for 11% of all GCTTSs reviewed. Of the 15 GCTTSs, only 1 required bone grafting after curettage, and only 2 recurred.

The present study found that two-thirds of lesions with bone changes associated with soft-tissue tumors of the hand were GCTTSs and that the rest were of many other types. Bone erosion associated with soft-tissue tumors of the hand suggests GCTTS, but other tumor diagnoses are possible. Glomus tumor of the fingertip or toes was reported to be associated with bone erosion in 25% of patients[12]. Intramuscular hemangioma of the extremity was reported to be associated with bone changes in 48% of patients[13]. Schwannoma is often associated with bone changes when it occurs in the vertebral or sacral nerve roots as a dumbbell tumor; however, only 1 patient was reported to have a schwannoma associated with erosion of the distal phalanx of the middle finger[14]. Synovial chondromatosis of a large joint was reported to be associated with bone erosion in 20% to 50% of patients[15].

The present study had several limitations. The subjects were limited to patients who had undergone surgery. Radiographic evaluation using only anteroposterior and lateral views was likely associated with measurement errors and was affected by a lesion's location on the axial plane. Differences in the original contour of the cortex among the erosive parts of bone were not considered when erosion was assessed; the diaphysis, epiphysis, and metaphysis each have a different cortex contour.

In conclusion, soft-tissue tumors of the fingers are frequently associated with bone erosion with clear margins. Most such tumors are GCTTSs, but many other tumors can be associated with bone erosion. The most vulnerable part of the hand is the palmar side of the phalanx from the distal shaft to the head. The bone erosion tends to extend deeper into the bone with limited widening and may become a "steep deep" erosion. Such an erosion, however, tends to require no major reconstruction after surgical curettage. These findings are useful for the diagnosis of soft-tissue tumors of the hand.

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