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Managing Atypical Chondrosarcomas: An Analysis of Prognostic Factors and Surgical Outcomes

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Abstract

Background

Chondrosarcomas are the second most common primary malignant cartilage tumors of the skeletal system. While they typically manifest in the pelvis and proximal long bones, atypical localizations—such as the hands, feet, and distal radius—account for less than 10% of all cases. Due to anatomical constraints in these regions, they present unique diagnostic and surgical challenges. The impact of parameters like tumor size and soft tissue extension on oncological survival remains highly debated. This study aims to evaluate the critical parameters affecting prognosis, the significance of surgical margins, and long-term oncological outcomes in a rare series of 20 atypical localization chondrosarcomas.

Methods

A retrospective review was conducted on 20 patients (13 males, 7 females; mean age 49.3 years) diagnosed with atypical localization chondrosarcoma between 2014 and 2024. Patients with classic chondrosarcomas located in the pelvis or proximal long bones (femur, humerus), those with less than 1 year of follow-up, and patients unwilling to participate were excluded from the study. Demographic details, tumor characteristics, histopathological data, and surgical treatments were analyzed. Functional outcomes were assessed using the Musculoskeletal Tumor Society (MSTS) score and the Visual Analog Scale (VAS) for pain. Oncological outcomes were evaluated via Kaplan-Meier survival analysis and Receiver Operating Characteristic (ROC) curve analysis.

Results

The mean follow-up period was 44.2 months, and the 5-year overall survival (OS) rate was 90%. Histological grade emerged as the strongest predictor of survival ($p = 0.001$). Soft tissue involvement significantly reduced the 5-year disease-free survival (DFS) from 91.2% to 51.4% ($p = 0.034$). Postoperative functional status was highly satisfactory, with a mean MSTS score of 24.2 out of 30.

Conclusion

Atypical localization chondrosarcomas are rare entities that can be easily overlooked due to their unusual presentation sites. While soft tissue extension is a critical determining factor for local control, tumor size serves as a significant warning indicator for systemic dissemination.

Introduction

Chondrosarcoma represents the second most frequent primary malignant bone tumor of the skeletal system, accounting for approximately 20% of all bone sarcomas (1). Characterized primarily by the production of a malignant cartilage matrix, it typically exhibits a low-to-moderate grade biological behavior (2). The disease predominantly affects adults between 40 and 70 years of age, whereas its occurrence in the pediatric population remains exceedingly rare (3). A distinct male predominance has been documented in the literature (4).

The vast majority of chondrosarcomas develop within axial skeletal regions, such as the pelvis, or the proximal ends of long bones (5). Although these tumors generally present as slow-growing masses, they are locally destructive; their metastatic potential is directly correlated with histological grade, with high-grade variants frequently metastasizing to the lungs (6). Apart from primary chondrosarcomas, secondary chondrosarcomas arising from pre-existing lesions—such as osteochondromas or multiple hereditary exostoses—constitute another clinically significant subgroup (7). Radiographically, they typically present as a lobulated, calcified mass featuring endosteal scalloping (8). Computed tomography (CT) and magnetic resonance imaging (MRI) serve as the cornerstones for evaluating local extension and planning surgical interventions. Wide surgical resection remains the gold standard of treatment (9). Because chondrosarcomas exhibit limited sensitivity to chemotherapy and radiotherapy, the quality of the surgical margin stands out as the most powerful determinant of prognosis (10).

Atypical localization chondrosarcomas constitute a rare subgroup that arises outside these classic axial and proximal long bone sites (3). Chondrosarcomas involving the small bones of the hands and feet account for merely 1–3% of all cases (5). Due to the difficulties encountered in differentiating them from benign enchondromas, they are frequently prone to delayed diagnosis. Tarsal bones, such as the calcaneus and talus, are even more rarely affected; however, these specific sites have been reported to carry a higher metastatic potential compared to other small bones (11). Scapular chondrosarcomas represent roughly 3–5% of cases and tend to present as large-volume masses owing to the flat bone anatomy (12). Although tumors in these atypical regions often display low histological grades, their local aggressiveness is pronounced, making surgical resection the primary therapeutic approach (2). However, achieving wide surgical margins can be technically challenging due to the intricate anatomical structures and functional requirements of the hands, feet, and scapula, thereby elevating the risk of local recurrence (8). Consequently, atypical chondrosarcomas are categorized as a distinct entity regarding their diagnostic, therapeutic, and prognostic features (10).

Because the current literature on atypical chondrosarcomas consists largely of isolated case reports or small case series, comprehensive data regarding their clinical behavior, surgical challenges, and long-term outcomes remain limited (13). Therefore, evaluating our series of 20 cases involving rare sites—such as the hand and foot bones, tarsal bones, and the distal radius—aims to contribute to a better understanding of both diagnostic challenges and therapeutic strategies, thereby addressing an important knowledge gap regarding threshold tumor sizes and the impact of soft tissue involvement on disease-free survival.

Materials and Methods

Following the approval of the institutional review board of Dr. Abdurrahman Yurtaslan Oncology Training and Research Hospital, a retrospective review was conducted on 20 patients who underwent surgical treatment for atypical localization chondrosarcomas (hand, foot, scapula, tarsal bones, distal radius, and scaphoid) between 2014 and 2024. The study was conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki. Patients with classic chondrosarcomas located in the pelvis or proximal long bones (femur, humerus), those with less than 1 year of follow-up, and patients unwilling to participate were excluded from the study. Surgical interventions were classified into three main categories based on the anatomical constraints of the atypical locations: wide local excision, ray amputation (specifically for digital and metacarpal/metatarsal lesions), and marginal excision. Postoperative surgical margins were histopathologically evaluated and categorized according to the residual tumor classification as R0 (microscopically negative margins, no residual tumor), R1 (microscopically positive margins, clear macroscopically but microscopic residual tumor), and R2 (macroscopically positive margins with gross residual tumor).

Demographic data (age, sex), tumor characteristics (side, localization, size), histopathological details (grade, soft tissue involvement), surgical interventions, and adjuvant therapies were extracted from medical records. Tumor size was defined as the maximum diameter (in centimeters) measured either on preoperative radiological imaging or within the definitive pathology specimen. Histological grading was performed in accordance with the World Health Organization (WHO) 2020 Classification of Tumors of Soft Tissue and Bone.

Functional outcomes were evaluated at the final postoperative follow-up using the Musculoskeletal Tumor Society (MSTS) scoring system and the Visual Analog Scale (VAS) for pain. Oncological outcomes were analyzed based on local recurrence, distant metastasis, and survival status.

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StatisticalAnalysis

Statistical analyses were performed using SPSS version 26.0 software. Descriptive statistics were expressed as means, standard deviations, medians, and frequency distributions. Overall survival (OS) and disease-free survival (DFS) rates were calculated using the Kaplan-Meier method, and differences between groups were compared using the log-rank (Mantel-Cox) test. ROC (Receiver Operating Characteristic) curve analysis was utilized to determine the predictive value and optimal cut-off thresholds of tumor size for distant metastasis and histological grade. A p-value < 0.05 was considered statistically significant.

Results

The mean age of the patient cohort was 49.3 years, with a distinct male predominance (65% male, 35% female). Notably, 65% of the tumors were located in acral regions (hands and feet), which underlines the 'atypical localization' focus of this study compared to classic chondrosarcoma series. The detailed demographic and localization data are summarized in Table 1.

Table 1
Demographic Distribution and Localization Parameters

Variable	Value (N = 20)
Age (Years)	49.3 (Range: 23–76)
Sex (Male/Female)	13 Male (65%) / 7 Female (35%)
Side (Right/Left)	11 Right (55%) / 9 Left (45%)
Follow-Up Period (Months)	44.2 (Range: 6–120)
Localization	Hand/Metacarpal/Phalanx: 5 (25%)
	Foot/Talus/Calcaneus: 8 (40%)
	Forearm/Radius/Ulna: 4 (20%)
	Other (Scaphoid, etc.): 3 (15%)

The majority of patients (85%) were diagnosed with low-to-moderate grade (Grade 1–2) chondrosarcoma. However, high-grade or dedifferentiated variants were present in 15% of the cohort, indicating that the risk of systemic progression cannot be disregarded even in atypical locations. Over a mean follow-up of 44.2 months, the local control rate was 85%. Comprehensive histopathological features and oncological outcomes are provided in Table 2.

Table 2
Histopathological Features and Oncological Outcomes

Parameter	Subgroup	Patient Count (N)	Percentage (%)
Histological Grade	Grade1	9	45%
	Grade2	8	40%
	Grade3/Dedifferentiated	3	15%
Softtissue Involvement	Present	7	35%
	Absent	13	65%
Local Recurrence	Present	3	15%
Distant Metastasis	Present	3	15%
Mortality (Exitus)	Present	2	10%

Following surgical treatment, the functional status of the patients was highly favorable, with a mean MSTS score of 24.2 out of 30. Despite the necessity of aggressive surgical margins or amputations in certain cases (particularly for phalanx and metacarpal involvements), a high postoperative quality of life was preserved. Clinical and functional scores are detailed in Table 3.

Table 3
Functional and Clinical Scores

Parameter	Mean Value	Range (Min–Max)
Postoperative Vas (Pain)	3.1	0–7
MSTS Score	24.2 / 30	11–30
Complication Rate	15% (3 patients)	Pathological fracture, Infection

All three patients who developed distant metastases had Grade 3 or dedifferentiated tumors. This confirms that histological grade is the strongest predictor of survival in atypical localizations ($p = 0.001$, Log-Rank / Mantel-Cox), with high-grade variants posing a significantly higher mortality risk than Grade 1 and 2 tumors.

Furthermore, the presence of soft tissue involvement was identified as a significant negative prognostic factor for DFS ($p = 0.034$). In patients exhibiting soft tissue extension, the 5-year DFS rate dropped to 51.4%, whereas patients without soft tissue extension demonstrated a significantly higher DFS rate of 91.2%. Survival outcomes stratified by soft tissue involvement and localization are presented in Table 4.

Table 4
Disease-Free Survival (DFS) and Soft Tissue Involvement Analysis

Parameter	Subgroup	Patients (N)	Recurrence/Metastasis (N)	5-Year Dfs Rate	P-Value
Entire Cohort	Overall	20	4	78.2%	—
Soft Tissue Involvement	Present	7	3	51.4%	0.034
	Absent	13	1	91.2%	
Localization	Acral (Hand/Foot)	13	2	82.5%	0.412
	Other (Radius/Ulna, etc.)	7	2	71.4%	

No statistically significant correlation was found between tumor size and local recurrence (p = 0.482). In atypical and acral locations, the limited anatomical space allows even small tumors to rapidly breach the bone cortex and invade adjacent soft tissues. Hence, rather than size alone, extra-compartmental extension (soft tissue involvement) better reflects biological aggressiveness and dictates local recurrence. Conversely, larger tumor size correlated significantly with high histological grade (p = 0.021) and an elevated risk of distant metastasis (p = 0.046). These correlations are displayed in Table 5.

Table 5
Correlation Between Tumor Size and Oncological Outcomes

Parameter	Mean Size (± Sd)	P-Value
Local Recurrence	(+) 3.4 cm vs (-) 3.9 cm	0.482
Metastasis	(+) 4.6 cm vs (-) 3.6 cm	**0.046**
Histological Grade	Grade 1 (2.8 cm) vs Grade 2/3 (4.8 cm)	**0.021**

Discussion

Chondrosarcomas typically exhibit a predilection for axial or proximal appendicular sites (14). Atypical localizations—including the hand, foot, and distal radius—represent less than 10% of all presentations in the literature (13, 15). The strict anatomical boundaries characterizing these regions heavily influence both the biological behavior of the tumor and its surgical management when compared with classic locations.

Histological grade remains widely accepted as the most critical parameter dictating prognosis in chondrosarcoma. In the 2020 WHO Classification, low-grade appendicular chondrosarcomas have been reclassified as 'Atypical Cartilaginous Tumors' (ACT) to emphasize their lower metastatic potential (16). The 100% overall survival rate observed among the Grade 1 and 2 cases in our series aligns perfectly

with these established literature parameters (17). Nevertheless, our cohort presented a 15% dedifferentiation rate, which culminated in an overall survival rate of 90% (18). This underscores the fact that when high-grade components are present, these tumors retain an aggressive clinical course despite their atypical, distal localizations.

One of the most clinically relevant findings of this study is the profound negative impact of soft tissue involvement on DFS ($p = 0.034$). In acral regions, the thinness of the bone cortex and the relative lack of robust soft tissue barriers facilitate early extra-compartmental extension (13, 19). Prior studies on hand and foot chondrosarcomas have reported that cortical destruction and soft tissue invasion dramatically escalate the risk of recurrence if intralesional surgery is performed. Our findings support this, as the 5-year DFS rate dropped to 51.4% in the presence of soft tissue involvement (20). This marked drop justifies the adoption of radical surgical interventions, such as ray amputations or wide local resections, over marginal resections in these challenging anatomical areas.

The prognostic significance of tumor size in chondrosarcoma has historically yielded conflicting views (21). In large bone series, a size threshold of 8 cm or greater is known to increase metastatic risk (22). In this study, higher size of tumors shows more metastasis and higher grade tumors comes with bigger size of tumors. Furthermore, the lack of association between size and local recurrence ($p = 0.482$) mirrors previous reports suggesting that recurrence depends more heavily on surgical margin adequacy and biological subtype rather than the baseline volumetric size of the mass.

Conclusions

This study provides valuable prognostic data through a relatively large series of 20 atypical localization chondrosarcomas, an entity frequently restricted to isolated case reports in the literature. Unlike classic long bone tumors, these rare distal presentations progress primarily when anatomical compartmental boundaries are breached rather than through volume increase alone. Given the narrow surgical fields available, achieving aggressive surgical margins and maintaining a rigorous postoperative follow-up protocol are essential. The primary limitations of this study include its retrospective design, single-center nature, and small sample size.

Declarations

Ethics Approval and Consent to Participate :

This study was approved by the Institutional Review Board and Ethics Committee of Dr. Abdurrahman Yurtaslan Oncology Training and Research Hospital. Informed consent was obtained from all individual participants included in the study.

Conflict of Interest :

The authors declare that they have no competing interests.

Consent for publication:

Not applicable.

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Author Contribution

T.G. determined the patient characteristics to be investigated in the study and established the foundation of the manuscript. A.P. and M.G. contributed to the writing of the introduction and statistical methods sections. H.T. and M.M. determined the interpretations of the statistical analyses, and C.U. assisted in the writing of the conclusion section. All authors contributed to the compilation, critical review, and approval of the final manuscript.

Data Availability

Availability of data and materials : The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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