e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(10); 1265-1273

Original Research Article

Clinicopathological Factors and Treatment Outcomes of Neoadjuvant Chemotherapy Among South Indian Patients with Osteosarcoma: A Single Institute Retrospective Study

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Received: 22-06-2023 Revised: 11-07-2023 / Accepted: 15-08-2023

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Conflict of interest: Nil

Abstract

Introduction: Osteosarcoma, despite its classification as a rare condition, paradoxically stands as the most common form of primary bone cancer that afflicts the pediatric and young adult population. This retrospective study delves into the clinicopathological characteristics, treatment outcomes, and overall survival of individuals with metastatic and non-metastatic osteosarcoma within the context of a selected tertiary care center in South India.

Methodology: This is a record based retrospective study that was conducted at a tertiary care hospital in South India. This research study was carried out over the period between January 2012 to December 2022. The collected data were entered into Epidata version 3.1, and subsequent data analysis was conducted using STATA version 12.0. Continuous variables were summarized as Mean (SD), while categorical variables were presented as Frequency (Proportions). Survival analysis is done by Kaplan–Meier method and is graphically represented with comparison between two factors done by log-rank test. For this study, a p-value of less than 0.05 was deemed as indicative of statistical significance.

Results: Out of 93 study participants with osteosarcoma, 80 study participants were non-metastatic. Among them, 75 study participants had undergone neoadjuvant chemotherapy. Among male patients, 40.4% were treated with AP, 8.5% with IAP, and 51.1% with MAP which was not found to be statistically significant. (P=0.508) No significant difference between the type of Neoadjuvant chemotherapy and the parameters such as clinical response and level of necrosis was found. Though MAP exhibited good responses but was also statistically insignificant. Out of 75 non-metastatic cases, 70 patients underwent surgery. While limb salvage was achieved in majority (51 patients) of them, there was no statistically significant difference was found between NACT groups. (P=0.278) Grade 4 neutropenia was reported in 29.6% in the AP group, 22.2% in the IAP group, and 48.1% in the MAP group, while Grade 4 mucositis was reported in none in the AP group, none in the IAP group, and 4 (100.0%) in the MAP group. Grade 3 CINV was reported in 27.3% in the AP group, 9.1% in the IAP group, and 63.6% in the MAP group. Among the 13 study participants with metastatic disease, the mean (SD) was found to be 30.54 (22.08), with male predominance (61.5%). Neurovascular deficit and joint space involvement was seen only in 2 (15.4%) patients and 2 (15.4%) patients respectively. Nodal metastasis was seen in 5 (38.5%) patients, while M1a (lung metastasis) contributed for 53.8% of the study participants.

Conclusion and Recommendations: In conclusion, the implications of this study include an enhanced understanding of osteosarcoma in the South Indian population, the tailoring of treatment approaches based on regional characteristics, the identification of prognostic factors, improved patient management, and the insight into further research and collaborations.

Keywords: Non-Metastasic, Osteosarcoma, Prognostic factors, Survival.

Introduction

Osteosarcoma, despite its classification as a rare condition, paradoxically stands as the most common form of primary bone cancer that afflicts the pediatric and young adult population [1]. The incidence of this malignancy spans across the spectrum of age groups, with reported rates ranging from 2.4 to 4.0 cases per million individuals, encompassing the entire age range. However, when

focusing on individuals between the ages of 0 to 24 years, the incidence becomes even more pronounced, with documented rates of 4.4 to 5.3 cases per million. Notably, osteosarcoma exhibits a striking gender bias, with men being affected 1.5 times more frequently than women. This demographic pattern adds an intriguing layer to the complexity of the disease's prevalence and raises questions about the underlying factors contributing to this gender discrepancy. [1, 2].

In the annals of medical history, patients diagnosed with non-metastatic osteosarcoma faced poor long-term survival prospects. Before the 1970s, the outlook for these individuals was notably bleak, with a meager survival rate of less than 20%. During that era, the prevailing approach to treatment primarily revolved around surgical intervention. In essence, the surgical removal of the tumor was the cornerstone of therapeutic efforts. [3] This marked a turning point in the management of the disease, offering newfound hope to patients and their families. The integration of chemotherapy into the treatment paradigm resulted in a remarkable improvement in the 5-year survival rate, pushing it beyond the 60% mark. [4–5].

During this time, the standard of care has evolved to encompass a comprehensive treatment approach, which combines neoadjuvant chemotherapy, surgical tumor resection, and adjuvant chemotherapy [6]. In pursuit of further enhancing survival rates and treatment efficacy, dedicated researchers have embarked on a quest to explore a plethora of drugs, administered at varying dosages and in different combinations, within controlled study groups [6,7]. Currently, in the ever-evolving landscape of osteosarcoma treatment, certain drugs have emerged as the most commonly employed and effective options. These include high-dose methotrexate, doxorubicin, cisplatin, and ifosfamide, each of which plays a crucial role in combating the disease. Among these, the combinatory regimen known as MAP, which comprises high-dose methotrexate, doxorubicin, and cisplatin, has gained recognition as a cornerstone of osteosarcoma treatment, especially in younger population. This approach is designed o improve response rates, thereby increasing the likelihood of therapeutic success [7].

Furthermore, researchers have introduced another alternate neoadjuvant regimen that includes ifosfamide, aiming to further improve treatment outcomes, while minimizing the toxicity of Methotrexate. This addition is part of ongoing efforts to refine therapeutic strategies, offering renewed hope for patients and their families by enhancing the chances of successful management and long-term survival [7,8]. Patients with unresectable primary tumors or metastases have poor clinical outcomes [9,10].

However, despite these extensive efforts and various treatment strategies, clinical trials have yet to yield conclusive evidence of a significant survival benefit. The quest to enhance the prognosis and treatment success for osteosarcoma patients continues to be a challenge, with researchers and healthcare providers striving to identify more effective therapeutic approaches. This retrospective study delves into the clinicopathological characteristics, treatment outcomes, and overall survival of individuals with metastatic and nonmetastatic osteosarcoma within the context of a selected tertiary care center in South India.

Methodology

The study was meticulously carried out at the esteemed Government Kilpauk Medical College Hospital. The study conducted a comprehensive retrospective analysis of patients diagnosed with osteosarcoma and treated from January 2017 to December 2022. Patient medical records were meticulously identified and reviewed, with all records being diligently maintained in the Institute Medical Records Department.

To ensure the quality and accuracy of the data, a set of well-defined inclusion and exclusion criteria were rigorously applied. The inclusion criteria encompassed both metastatic and nonmetastatic osteosarcoma cases, ensuring that a comprehensive spectrum of the disease was examined. Conversely, patients with benign conditions or those with incomplete or inadequate medical records were thoughtfully excluded from the study, maintaining the integrity and reliability of the data.

A standardized data extraction form was employed to systematically collect pertinent information from the patient medical records. This form was designed to encompass a wide array of variables. Demographic data, including age and gender, were diligently recorded, providing a snapshot of the patient population under study. Clinical features, such as the site of the primary tumor and the presence of metastasis, were meticulously documented, facilitating a detailed clinical characterization of each case. Furthermore, histopathological reports were subjected to careful analysis, allowing for the determination of the histological subtype and tumor grade of each case, which is paramount in understanding the disease's pathological characteristics.

The treatment modalities received by the patients were thoroughly documented, creating a comprehensive treatment profile. This encompassed surgical interventions, chemotherapy regimens, and radiotherapy.

Specific surgical procedures, such as limb salvage surgery or amputation, were meticulously noted.

Likewise, chemotherapy protocols, including drug regimens, doses, and cycles, were documented in detail, and any reported adverse events or complications related to treatment were captured. Additionally, the utilization of radiotherapy, including information regarding target sites and dosages, was recorded.

Treatment responses were assessed through a systematic process that involved reviewing imaging reports, clinical evaluations, and histopathological findings. Standardized guidelines were adhered to for evaluating treatment responses, which involved criteria such as clinical assessments, imaging characteristics and histological response.

The study extended its analysis to encompass survival outcomes, which are integral in understanding the long-term effects of the disease and the treatments administered. Specifically, the study examined both overall survival and disease-free survival. Overall survival was defined as the duration from the time of diagnosis to the point of death from any cause, providing a comprehensive understanding of patient longevity. Disease-free survival, on the other hand, was defined as the period from diagnosis to either disease recurrence, metastasis, or death, providing insights into the persistence or reemergence of the condition. Survival analyses were carefully conducted, tracking patients from the date of diagnosis until their last follow-up or death. Patients who defaulted after diagnosis and those lost to follow-up during treatment were censored to ensure accurate survival analysis. Survival rates were estimated using the Kaplan-Meier method, and survival curves were thoughtfully generated to illustrate the survival trends observed within the patient cohort.

The collected data were entered into Epidata version 3.1, and subsequent data analysis was conducted using STATA version 12.0. (11, 12) A range of statistical tests, including chi-square tests, Fisher's exact tests, and t-tests, were thoughtfully employed based on the type of variables under consideration, whether categorical or continuous. In keeping with established conventions, a p-value of less than 0.05 was deemed statistically significant, signifying associations or differences that warranted attention and further exploration.

To ensure the ethical integrity of the study, it obtained the requisite ethical approval from the Institutional Review Board, which underscores the commitment to adhering to ethical principles and guidelines, safeguarding the welfare and privacy of the patients whose medical records were scrutinized in this retrospective investigation.

Results

Out of 93 study participants with osteosarcoma, 80 study participants were non-metastatic. Among them, 75 study participants had undergone treatment with neoadjuvant chemotherapy. Table 1 shows that among female patients, 28.6% received AP, 14.8% received IAP, and the majority, 57.1%, received MAP. Among male patients, 40.4% were treated with AP, 8.5% with IAP, and 51.1% with MAP, though there was a difference between the groups, but it was not statistically significant. (P=0.508) Among patients without neurovascular deficits, 39.7% received AP, 8.8% received IAP, and 51.5% received MAP, with a borderline p-value of 0.062. (Table 1)

Histological subtypes of osteosarcoma were analyzed in relation to neoadjuvant chemotherapy. Subtypes included unspecified conventional, chondroblastic, fibroblastic, osteoblastic, periosteal, and telangiectatic. Notably, 68.2% of chondroblastic osteosarcoma patients received MAP. The p-value for this analysis is 0.226, suggesting no significant association between histological subtype and chemotherapy selection. (Table 1).

Table 1: Comparison of sociodemographic, clinicopathological profile with Neoadjuvant chemotherapy among the study participants with non-metastatic osteosarcoma (N=75)

Variable	NACT								P-Value
	AP, n	(%)	IAP, n	(%)	MAP, n	(%)	Total, n	(%)	
Gender									
Female	8	28.6%	4	14.8%	16	57.1%	28	100.0%	0.508
Male	19	40.4%	4	8.5%	24	51.1%	47	100.0%	
Performance status									
1	26	36.6%	7	9.9%	38	53.5%	71	100.0%	0.617
2	1	25.0%	1	25.0%	2	50.0%	4	100.0%	
Neurovascular Deficit	27	39.7%	6	8.8%	35	51.5%	68	100.0%	0.062
Joint space involvement	24	37.5%	6	9.4%	34	53.1%	64	100.0%	0.619
Histology									
Unspecified conventional	10	33.3%	5	16.7%	15	50.0%	31	100.0%	0.226

Chondroblastic	7	31.8%	0	0.0%	15	68.2%	22	100.0%	
Fibroblastic	3	42.9%	1	14.3%	3	42.9%	7	100.0%	
Osteoblastic	4	57.1%	1	14.3%	2	28.6%	7	100.0%	
Periosteal	2	100.0%	0	0.0%	0	0.0%	2	100.0%	
Telangiectatic	0	0.0%	1	16.7%	5	83.3%	6	100.0%	
	1	100.0%	0	0.0%	0	0.0%	100	100.0%	
Site									
Femur	15	32.6	5	10.9	26	56.5	46	100.0%	0.769
Tibia	4	36.4%	1	9.1%	6	54.5%	11	100.0%	
Humerus	2	33.3%	2	33.3%	2	33.3%		100.0%	
Fibula	2	40.0%	0	0.0%	3	60.0%	5	100.0%	
Ilium	0	0.0%	0	0.0%	2	100.0%	2	100.0%	
acetabulum	1	100.0%	0	0.0%	0	0.0%	1	100.0%	
Ulna	1	50.0%	0	0.0%	1	50.0%	2	100.0%	
Radius	1	100.0%	0	0.0%	0	0.0%	1	100.0%	
mandible	1	100.0%	0	0.0%	0	0.0%	1	100.0%	
Grade									
1	2	20.0%	2	20.0%	6	60.0%	10	100.0%	0.75
2	9	37.5%	2	8.3%	13	54.2%	24	100.0%	
3	16	39.0%	4	9.8%	21	51.2%	41	100.0%	
T- stage									
1	6	35.3%	1	5.9%	10	58.8%	17	100.0%	0.22
2	21	39.6%	7	13.2%	25	47.2%	53	100.0%	
3	0	0.0%	0	0.0%	5	100.0%	5	100.0%	
No. of cycles									
2	0	0.0%	1	50.0%	1	50.0%	2	100.0%	0.081
3	12	30.0%	4	10.0%	24	60.0%	40	100.0%	
4	9	34.6%	2	7.7%	15	57.7%	26	100.0%	
5	2	100.0%	0	0.0%	0	0.0%	2	100.0%	
6	4	80.0%	1	20.0%	0	0.0%	5	100.0%	

The analysis further explores T-stage (tumor stage) and its relation to neoadjuvant chemotherapy. Tumor stages are categorized as Stage I, II, III. Notably, all T-stage III patients received MAP. However, the p-value for this analysis is 0.22, indicating no substantial association between T-stage and neoadjuvant chemotherapy. (Table 1)

Table 2: Comparison of clinical and pathological response based on Neoadjuvant Chemotherapy among the study participants with non-metastatic osteosarcoma (N=75)

Variable	NACT								P-Value
	AP, n	(%)	IAP, n	(%)	MAP, n	(%)	Total, n	(%)	
Response to NACT (clinical)									
Good	14	32.6%	4	9.3%	25	58.1%	43	100.0%	0.771
Progressive	11	42.3%	4	15.4%	11	42.3%	26	100.0%	
Stable	3	50.0%	0	0.0%	3	50.0%	6	100.0%	
Necrosis									
<90	15	37.5%	5	12.5%	20	50.0%	40	100.0%	0.207
≥90	5	22.7%	1	4.5%	16	72.7%	22	100.0%	

Table 2 reveals that there is no significant difference between the type of neoadjuvant chemotherapy and clinical response (P=0.771) or the level of necrosis in patients with non-metastatic osteosarcoma. These findings imply that clinical and pathological responses do not appear to be strongly influenced by the choice of neoadjuvant chemotherapy regimen.

Table 3: Comparison of limb salvage and Disease free interval based on Neoadjuvant Chemotherapy among the study participants with non-metastatic osteosarcoma (N=75)

Variable	NACT								P-Value
	AP, n	(%)	IAP, n	(%)	MAP, n	(%)	Total, n	(%)	
Surgery done	24	34.3%	7	10.0%	39	55.7%	70	100.0%	0.474
Limb salvage	15	29.4%	5	9.8%	31	60.8%	51	100.0%	0.278
DFI									
< 6 months	11	55.0%	3	15.0%	6	30.0%	20	100.0%	0.121
≥ 6 months	1	20.0%	1	20.0%	3	60.0%	5	100.0%	
NA	15	31.2%	4	8.3%	29	60.4%	48	100.0%	

Out of 75 non-metastatic cases, 70 patients underwent surgery. While limb salvage was achieved in majority (51 patients) of them, but it was not found to be statistically significant. Table 3 suggests that there is no significant association between the type of neoadjuvant chemotherapy and the choice of surgery or limb salvage among patients with non-metastatic osteosarcoma. Additionally, there is no statistical significant difference elicited between neoadjuvant chemotherapy regimens and the duration of Disease-Free Interval. (Table 3)

Table 4: Comparison of toxicity profile based on Neoadjuvant Chemotherapy among the study participants with non-metastatic osteosarcoma (N=75)

Variable	NACT								P-Value
	AP, n	(%)	IAP, n	(%)	MAP, n	(%)	Total, n	(%)	
Neutropenia									
2	5	41.7%	0	0.0%	7	58.3%	12	100.0%	0.18
3	14	38.9%	2	5.6%	20	55.6%	36	100.0%	
4	8	29.6%	6	22.2%	13	48.1%	27	100.0%	
Thrombocyto -penia									
1	2	50.0%	0	0.0%	2	50.0%	4	100.0%	0.186
2	9	25.7%	3	8.6%	23	65.7%	35	100.0%	
3	10	37.0%	5	18.5%	12	44.4%	27	100.0%	
4	6	66.7%	0	0.0%	3	33.3%	9	100.0%	
Mucositis									
0	0	0.0%	1	50.0%	1	50.0%	2	100.0%	0.291
1	5	29.4%	1	5.9%	11	64.7%	17	100.0%	
2	17	44.7%	4	10.5%	17	44.7%	38	100.0%	
3	5	35.7%	2	14.3%	7	50.0%	14	100.0%	
4	0	0.0%	0	0.0%	4	100.0%	4	100.0%	
CINV									
1	13	39.4%	4	12.1%	16	48.5%	33	100.0%	0.946
2	11	36.7%	3	10.0%	16	53.3%	30	100.0%	
3	3	27.3%	1	9.1%	7	63.6%	11	100.0%	
4	0	0.0%	0	0.0%	1	100.0%	1	100.0%	

Grade 4 neutropenia was reported in 29.6% in the AP group, 22.2% in the IAP group, and 48.1% in the MAP group, while Grade 4 mucositis was reported in none in the AP group, none in the IAP group, and 4 (100.0%) in the MAP group. Grade 3 CINV was reported in 27.3% in the AP group, 9.1% in the IAP group, and 63.6% in the MAP group. Table 4 suggests that there is no significant association between the type of neoadjuvant chemotherapy and the observed toxicities, including neutropenia, thrombocytopenia, mucositis, and chemotherapy-induced nausea and vomiting (CINV) among patients with non-metastatic osteosarcoma.

Table 5: Comparison of palliative treatment and overall survival based on Neoadjuvant Chemotherapy among the study participants with non-metastatic osteosarcoma (N=75)

Variable	NACT	P-

	AP, n	(%)	IAP, n	(%)	MAP, n	(%)	Total, n	(%)	Value
Palliative treatment received	12	48.0%	4	16.0%	9	36.0%	25	100.0%	0.100
Defaulted	0	0.0%	1	33.3%	2	66.7%	3	100.0%	0.255
1-year survival	25	36.8%	7	10.3%	36	52.9%	68	100.0%	0.752
2-year survival	17	33.3%	5	9.8%	29	56.9%	51	100.0%	0.609
5-year survival	7	28.0%	3	12.0%	15	60.0%	25	100.0%	0.505

For patients who received palliative treatment, 48.0% were in the AP group, 16.0% in the IAP group, and 36.0% in the MAP group, while among patients who defaulted from treatment, none were in the AP group, 33.3% in the IAP group, and 66.7% in the MAP group. Both were not found to be statistically significant. For patients with 5-year survival, 28.0% were in the AP group, 12.0% in the IAP group, and 60.0% in the MAP group of neoadjuvant chemotherapy, which were not found to be statistically significant. (P=0.505) (Table 5). Among the 13 study participants with metastatic condition, the mean (SD) was found to be 30.54 (22.08), with male predominance (61.5%). Neurovascular deficit and joint space involvement was seen only in 2 (15.4%) patients and 2 (15.4%) patients respectively.

Nodal metastasis was seen in 5 (38.5%) patients, while M1a (Lung metastasis) contributed for 53.8% of the study participants. All the 13 patients received palliative chemotherapy, while majority (53.8%) received MAP. Good/ Stable response was seen in 5 (38.5%) patients in metastatic condition.

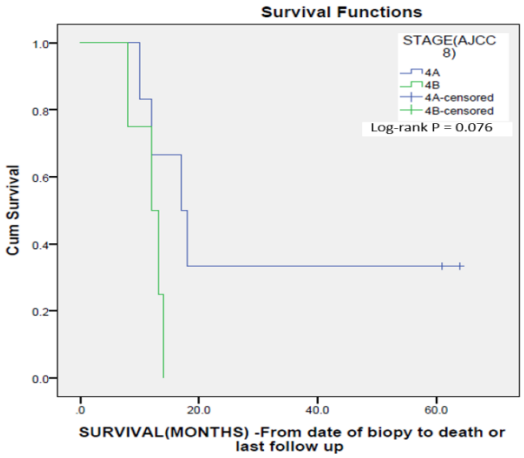

Figure 1: Kaplan–Meier curves for overall survival analysis based on stage (AJCC-8) among the study participants with non-metastatic osteosarcoma (N=75)

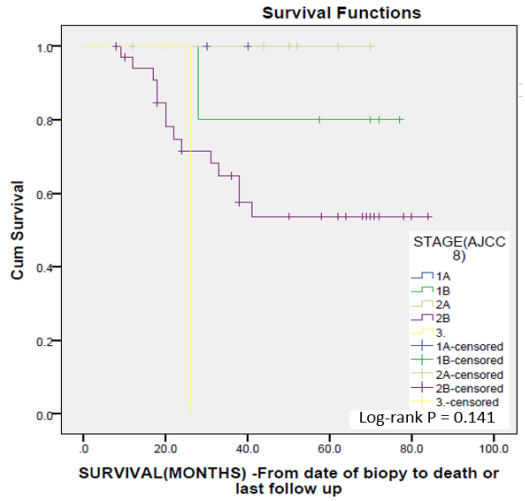

Figure 2: Kaplan–Meier curves for overall survival analysis based on stage (AJCC-8) among the study participants with metastatic osteosarcoma (N=13)

Figure 1 shows the Kaplan–Meier survival curve for overall survival based on stage (AJCC-8) among the study participants with non-metastatic osteosarcoma. The overall survival based on stage (AJCC-8) among the study participants with metastatic osteosarcoma is depicted in Figure 2.

Discussion

In relation to patient characteristics and demographic data in our study, our findings align with previous research indicating a higher prevalence of osteosarcoma in men compared to women [13–17]. Regarding the response to neoadjuvant chemotherapy, a significant proportion of patients in the MAP group exhibited a "Good" response (58.1%). In contrast, the AP and IAP groups showed lower percentages of "Good" responses at 32.6% and 9.3%, respectively. Notably, the AP group had a higher prevalence of "Progressive" responses (42.3%), mirroring the results reported by Chui et al. [18]. These outcomes imply that, in this specific cohort, the MAP regimen may yield a more favorable clinical response. However, it's crucial to emphasize that these disparities did not reach statistical significance, underscoring the potential influence of other factors such as individual patient characteristics, dose modifications and tumor biology on the clinical response.

Patients in the MAP group achieved a higher level of necrosis (≥90%) compared to the AP and IAP groups. Although the p-value (0.207) indicates no statistically significant difference, a higher degree of necrosis is generally associated with improved survival rates. Therefore, while not definitive, these findings emphasize the potential benefits of the MAP regimen and underscore the importance of considering the extent of necrosis when evaluating treatment response.

The receipt of palliative treatment did not significantly differ among the chemotherapy regimens, as indicated by the p-value (0.100). However, it's important to note that the decision to administer palliative treatment is influenced by various clinical factors, including patient preferences, comorbidities, and treatment response.Default rates were assessed, and although the p-value (0.255) did not reach statistical significance, the difference between the chemotherapy regimens was notable. Default rates were highest in the IAP and MAP groups, highlighting the need for strategies to support patient adherence to treatment protocols and managing adverse effects of chemotherapy. Our current study revealed that a significant proportion of osteosarcoma patients were characterized as poor responders to chemotherapy, in line with the observations made in a study by Chui et al., where 60% of high-grade osteosarcoma cases demonstrated a poor chemotherapy response. Additionally, these findings are consistent with prior research conducted by Prabowo et al. [18, 19], further highlighting the recurring pattern of chemotherapy resistance in osteosarcoma, which remains a challenging aspect of its treatment.

Survival outcomes at 1 year, 2 years, and 5 years were also evaluated. No statistically significant differences were observed among the neoadjuvant chemotherapy regimens. These findings underscore the complexity of factors influencing survival outcomes, such as surgical resection margins, tumor size, and patient-specific characteristics.

Prior research has suggested that a subset of osteosarcoma patients achieve a cure through treatment, meaning they do not experience cancer progression during their lifetime [20, 21]. However, due to censoring in the data, it remains uncertain whether patients with relatively short follow-up periods who were last observed alive without disease progression are genuinely cured. In contrast to traditional survival analysis methods that primarily estimate overall cohort survival, mixture cure models offer the ability to assess the probability of being cured and the progression-free survival (PFS) if a patient is not cured. From a clinical perspective, understanding the cure fraction can be more informative than relying solely on 5-year survival rates, particularly for young osteosarcoma patients, who represent a significant portion of those affected by the disease. Most notably, cure models enable the examination of separate covariate effects on both cure and PFS for patients who are not cured, providing more nuanced insights into these effects [22-25].

This study fills a crucial gap in the literature by providing a comprehensive analysis of osteosarcoma in the South Indian population. By examining the clinicopathological characteristics, treatment outcomes, and survival rates specific to this region, the study enhances our understanding of the disease in this particular context. It provides valuable insights into potential differences in disease presentation, treatment response, and prognosis compared to other populations, thereby facilitating more targeted and effective management strategies. This study lays the foundation for further research on osteosarcoma in South India. The identified gaps and limitations can guide future studies, including prospective investigations and multicenter collaborations. The study's findings can serve as a reference for benchmarking outcomes and comparing treatment strategies across different regions, ultimately contributing to the development of standardized guidelines and improved outcomes for osteosarcoma patients globally.

Limitations: The limitations of this study include its retrospective design, which may be prone to selection bias and incomplete data. Additionally, the study's single-center nature may limit the generalizability of the findings to other regions. Despite these limitations, this study provides valuable insights into the clinicopathological characteristics, treatment outcomes, and survival

rates of individuals with metastatic and nonmetastatic osteosarcoma in the South Indian population. These findings underscore the multifaceted nature of osteosarcoma management. Individualized treatment approaches, diligent monitoring of side effects, and a multidisciplinary care team remain essential in optimizing patient outcomes. Future research with larger sample sizes may offer more definitive insights into the observed trends.

Conclusion

In conclusion, the implications of this study include an enhanced understanding of osteosarcoma in the South Indian population, the tailoring of treatment approaches based on regional characteristics, the identification of prognostic factors, improved patient management, and the stimulation of further research and collaborations. These implications have the potential to improve patient outcomes and advance the field of osteosarcoma management in South India and beyond. Moreover, the findings from the current study serve as a foundation for future research and improvements in the care of osteosarcoma patients, with the ultimate goal of enhancing their quality of life and survival outcomes.

Funding: Nil

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