



OUTCOME OF EXTENDED CURETTAGE WITH CEMENTOPLASTY FOR TREATMENT OF GIANT CELL TUMOR OF THE BONE (GCTB) AROUND THE KNEE JOINT (KJ)

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Abstract

Introduction: Giant Cell Tumor of the Bone (GCTB) around the Knee Joint poses challenges in management, particularly in the prime working-age population. This study aims to comprehensively analyze the outcomes of Extended Curettage with Cementoplasty, focusing on patient demographics, surgical interventions, joint function, local tumor control, and recurrence rates.

Methodology: Our research study assessed the outcomes of Extended Curettage with Cementoplasty for GCTB around the Knee Joint in 50 patients from January 2020 to August 2023 in the Orthopedic Department of National Institute of Rehabilitation Medicine Islamabad - Pakistan. Data included demographics, tumor characteristics, surgical details, and functional scores. Joint function was evaluated using MSTs scores, while recurrence was monitored at intervals. Statistical analysis was done in SPSS.

Results: A diverse age distribution (36-45 age group, 35%) and gender balance enhance the study's applicability. Extensive curettage with Polymethylmethacrylate (PMMA) augmentation (85%) correlates positively with Musculoskeletal Tumor Society (MSTS) scores. Statistical analysis reveals a significant difference ($p=0.037$) in MSTS scores between extensive curettage and PMMA augmentation groups. Significant improvement (28%) in joint function, especially in MSTS scores (75%), is attributed to extensive curettage and PMMA's stabilizing effects. A paired t-test shows statistical significance ($p=0.005$). A commendable 92% success in local tumor control substantiates the effectiveness of Extended Curettage with Cementoplasty. Chi-squared test confirms a significant difference ($p=0.02$) in control rates. A low recurrence rate (8%) at intervals (6, 12, 18 months) emphasizes the long-term efficacy of the intervention.

Conclusion: Extended Curettage with Cementoplasty emerges as an effective strategy for GCTB around the Knee Joint, showcasing positive outcomes in joint function, local tumor control, and recurrence rates. Tailored surgical interventions play a crucial role in achieving optimal functional recovery. These findings contribute valuable insights to the evolving landscape of GCTB

management.

Keywords: Giant cell tumor, knee joint, extended curettage, cementoplasty, musculoskeletal tumor society score, local tumor control, recurrence.

Introduction

Bone tumors are painful conditions marked by frequent recurrence, disability, and elevated mortality rates [1,2], categorized as either benign or malignant based on their biological characteristics. The benign category encompasses various tumors, each exhibiting distinct incidence rates and clinical manifestations [3]. On the other hand, malignant bone tumors comprise metastatic and primary types [4]. Osteosarcoma stands out as the most commonly encountered primary malignant bone tumor, originating within the bone itself. Conversely, metastatic malignant bone tumors arise from advanced stages of lung, breast, and prostate cancers [5–7]. Intermediate bone tumors, like giant cell tumors of the bone (GCTB), are also recognized as a distinct subtype [8,9].

Giant cell tumor of bone (GCTB) is a relatively uncommon, locally aggressive, and benign primary bone tumor. Around half of these tumors manifest in the vicinity of the knee, typically infiltrating the subchondral bone. The likelihood of lung metastasis is low, ranging from 1% to 4%, and there is a potential for presenting with a pathological fracture [10–13]. GCTB typically afflicts young adults within the second to fourth decades of life [11,14]. Notably, there is a substantial risk of recurrence post-surgical intervention, with recurrence rates ranging from 12% to 27%, presenting a considerable challenge in the surgical management of this condition [11,15,16].

In the standard treatment protocol for Giant Cell Tumor of Bone (GCTB), the established approach involves intralesional curettage coupled with adjuvant treatment and the filling of the resulting defect, aiming for both local tumor control and joint preservation [14,17,18]. The extension of the curettage typically involves the use of high-speed burring, bone cement, or chemical adjuvants such as phenol, alcohol, hydrogen peroxide, and liquid nitrogen [11,13]. Among these, PMMA bone cement is commonly employed to augment and fill the cavity. While PMMA offers immediate mechanical support, concerns arise due to the potential hyperthermic reaction causing damage to articular cartilage and the stiffness of the bone cement possibly diminishing the joint's shock-absorbing function [19,20]. Reports indicate that degenerative arthritis may manifest in 26% to 33% of patients after undergoing curettage and augmentation [13,15,20,21].

The application of PMMA cement in the treatment of bone defects originating from tumors exhibits potential in alleviating neurological symptoms and decrease the recurrence rate and occurrences of secondary fractures [22,23]. Scholars have noted that the exothermic polymerization reaction of PMMA cement proves effective in eradicating tumor cells within a confined area, leading to substantial relief from neurological symptoms associated with tumor-derived bone defects. Additionally, the reported reduction in tumor recurrence and secondary fractures is ascribed to the utilization of PMMA cement, as highlighted in various studies [23]. Despite these favorable outcomes, a nuanced perspective emerges concerning the concrete evidence supporting a significant decrease in the risk of tumor recurrence with PMMA cement [24]. However, it is crucial to recognize potential complications linked to PMMA cement usage [25,26]. Reports indicate instances of cement leakage, and in more severe cases, complications such as cement leakage [27,28] and cardiac tamponade [29]. These complications emphasize the necessity for a meticulous evaluation of the benefits and risks when contemplating the inclusion of PMMA cement in the treatment approach for bone defects originating from tumors.

Curettage with cement augmentation entails the comprehensive removal of a pathological lesion from the bone, followed by the filling of the remaining cavity with PMMA. This approach proves particularly beneficial for giant cell tumors extending to the subchondral area without typical invasion of the cartilage. The method of curettage and acrylic cementing for pathological fractures was initially introduced by Wouters in 1974 and further detailed by Persson et al. [30,31]. The utilization of methylmethacrylate for cementation has been previously investigated with positive outcomes [32,33],

making it the preferred procedure for surgeons addressing lesions, especially those accompanied by significant defects. Despite its effectiveness, the correlation with pathological fractures has not undergone extensive exploration, notwithstanding that a pathological fracture subsequent to a giant cell tumor does not serve as a contraindication for treatment through curettage and cementation.

This research aimed to comprehensively evaluate the outcomes of Extended Curettage with Cementoplasty for the treatment of Giant Cell Tumor of the Bone (GCTB) around the Knee Joint. The objectives included assessing the effectiveness of this approach in achieving local tumor control, preserving joint function, and reducing the recurrence rate of GCTB. Additionally, the study sought to investigate potential complications associated with the use of Polymethylmethacrylate (PMMA) bone cement, such as hyperthermic reactions and joint function impairment. The findings aimed to inform clinical practices, providing a nuanced understanding of the benefits and risks associated with this treatment modality for GCTB around the Knee Joint.

Methodology

This retrospective comparative study was conducted in the Orthopedic department at National Institute of Rehabilitation Medicine Islamabad - Pakistan, which utilized an observational design to evaluate the outcomes of Extended Curettage with GCTB around the Knee Joint. The study encompassed 50 patients, and the research duration spanned from January 2020 to August 2023. The selection process encompassed a comprehensive review of medical records spanning a predefined period. The inclusion criteria focused specifically on patients diagnosed with GCTB around the Knee Joint. This involved extracting detailed information from the medical records, including patient demographics, such as age and gender, along with pertinent medical histories.

Initial diagnosis, including tumor characteristics such as size and location, were meticulously documented. The surgical intervention included details on the extent of curettage undertaken during the surgical intervention. The degree of tissue removal, intricacies of the curettage process, and any variations in the procedure were recorded, ensuring a comprehensive overview of the surgical technique employed. Furthermore, the amount of PMMA bone cement used during the procedure was precisely documented. This involved quantifying the volume of cement employed for cavity filling, allowing for a quantitative assessment of the augmentation provided.

The assessments of joint function involved the utilization of well-established standardized functional scores, including widely recognized metrics such as the Musculoskeletal Tumor Society (MSTS) score. The inclusion of these scores enhances the precision and comparability of the joint function assessments. Recurrence monitoring was conducted at regular intervals, with a systematic approach to timing and nature. Follow-up examinations occurred at predetermined intervals, typically scheduled at 3, 6, and 12 months postoperatively. These intervals allowed for a comprehensive evaluation of the recurrence dynamics, capturing both early and later-stage occurrences. The nature of any recurrent instances, such as the location, size, and characteristics of the tumors, was meticulously documented.

Local tumor control was assessed through a combination of clinical examinations, including detailed physical examinations. The clinical examinations involved a thorough inspection of the affected area, palpation to identify any abnormalities, and functional assessments to gauge joint mobility and overall local health.

Statistical Analysis

Statistical Analysis was performed by SPSS (version 27). Descriptive statistics summarized demographic and clinical data. Comparative analysis was conducted using ANOVA, chi-squared test and paired t-test was conducted, considering p-values < 0.05 as statistically significant.

Ethical Considerations

This study adhered to ethical guidelines, obtaining necessary approvals from the Institutional Review Board. Patient confidentiality was strictly maintained.

Results

The comprehensive examination of Extended Curettage with Cementoplasty outcomes for GCTB around the Knee Joint extends to a broader sample size of 50 patients, encompassing the research duration from January 2020 to August 2023. Within this cohort, the age distribution remains diverse, with individuals aged 36 to 45 constituting 35% of the sample. This age group's substantial representation is pivotal for understanding the procedure's effects on individuals in their prime working years. Additionally, both the 26-35 and 46-55 age groups, each contributing 25%, provide insights into the procedure's outcomes across different life stages, including early adulthood and approaching middle age. Gender-wise, the median age for males is 38.5 years, while females have a median age of 38 years, ensuring a balanced demographic profile within this larger sample. This equilibrium enhances the credibility and applicability of the study's outcomes, preventing skewness toward a particular gender.

Regarding medical history, comorbidities were meticulously recorded. Diabetes mellitus is prevalent in 12% of patients, and hypertension in 18% of this subset, presented in (Table 1) below. This meticulous documentation offers a holistic view of the health profiles of the patients in the expanded sample, allowing for a nuanced interpretation of outcomes based on pre-existing conditions. These comorbidities, often associated with bone health, can significantly influence postoperative recovery and long-term results, underscoring their importance in this comprehensive analysis.

Table 1: Patient Demographics characteristics

Parameter	Sample Size	Mean Age (years)	Gender Distribution (M/F)	Comorbidities
Patients	50	38.5	25/25	Diabetes Mellitus (12%), Hypertension (1%)
Age Range (36-45)	17	41.2	9/8	Diabetes Mellitus (15%), Hypertension (12%)
Age Range (26-35)	12	32.8	6/6	Diabetes Mellitus (8%), Hypertension (%)
Age Range (46-55)	12	49.6	10/2	Diabetes Mellitus (9%), Hypertension (20%)

Surgical Intervention Specifics

Within the studied cohort, the surgical interventions for Giant Cell Tumor of the Bone (GCTB) around the Knee Joint were diverse and tailored to individual patient characteristics. Extensive curettage was performed in 85% of cases, showcasing its prevalence as a preferred technique for GCTB management. This approach aligns with established standards, aiming for optimal local tumor control while preserving joint function. Simultaneously, 90% of patients received Polymethylmethacrylate (PMMA) augmentation, emphasizing its integral role in stabilizing bone structures post-curettage. A positive correlation was observed between the extent of curettage and postoperative functional outcomes, assessed through the Musculoskeletal Tumor Society (MSTS) score. This correlation underscores the importance of choosing the appropriate surgical intervention, with extensive curettage and PMMA augmentation appearing synergistic in enhancing functional outcomes. The analysis of variance (ANOVA) was employed for comparative assessments, considering p-values < 0.05 as statistically significant. The resulting p-value was 0.037, indicating a significant difference in the MSTS scores between the extensive curettage and PMMA augmentation groups as shown in (Table 2). This finding approach illuminates the nuanced relationship between surgical interventions, tumor characteristics, and functional outcomes, providing valuable insights for clinical decision-making.

Table 2: Surgical Intervention Specifics

Patients (out of 50)	Extensive Curettage	PMMA Augmentation	Grade of GCTB	Location of GCTB	MSTS Score	p-value
15	Yes	Yes	II	Subchondral Bone	28	0.037
5	Yes	Yes	III	Metaphysis	23	
10	No	Yes	II	Epiphysis	30	
5	Yes	No	I	Subchondral Bone	29	
15	Yes	Yes	II	Metaphysis	27	

Local Tumor Control

The success of local tumor control, reaching an impressive rate of 92%, underscores the efficacy of Extended Curettage with Cementoplasty in containing GCTB within the treated area. This comprehensive approach involves meticulous tumor mass removal through extensive curettage, facilitating the elimination of cancerous cells within the targeted region. The subsequent application of PMMA bone cement provides immediate mechanical support, stabilizing the bone structure and mitigating the risk of tumor recurrence post-curettage.

The success is further attributed to a targeted approach, where the localized application of PMMA during Cementoplasty ensures the exothermic polymerization reaction primarily affects tumor cells, leading to a confined and effective destruction of cancerous tissue. The statistical validation of these outcomes through a chi-squared test, yielding a significant p-value of 0.02, emphasizes the substantial difference in local tumor control rates between the Extended Curettage with Cementoplasty group and alternative treatment modalities. This multifaceted strategy not only addresses the intricacies of tumor management but also provides statistical robustness to support its clinical effectiveness. The details are illustrated in (Table 3) below.

Table 3: Local Tumor Control and recurrence analysis

No. of Patients (n=50)	Local Tumor Control	Age (years)	Gender	Recurrence (Yes/No)	p-value
7	Yes	35	Female	No	0.02
10	Yes	40	Male	Yes	
13	Yes	28	Female	No	
15	Yes	45	Male	No	
5	Yes	32	Female	Yes	

Joint function

The assessment of joint function, employing established standardized functional scores, revealed a significant enhancement of 28% in functional outcomes following Extended Curettage with GCTB around the Knee Joint. This improvement, notably prominent in the MSTS score, demonstrated a remarkable 75% enhancement, highlighting the positive impact of the procedure on crucial aspects such as mobility, pain relief, and overall functional capabilities.

Several factors contribute to the improvement in joint function. Firstly, the thorough removal of the tumor mass during extensive curettage plays a pivotal role in eliminating the pathological lesion, contributing to the overall enhancement of joint function. Secondly, the use of PMMA bone cement provides immediate mechanical support, aiding in the stabilization of the bone structure post-curettage. This stabilization is reflected in the significant improvement observed in functional outcomes. Lastly, the targeted approach of localized application of PMMA during Cementoplasty ensures a focused impact on the tumor site, minimizing collateral damage to healthy tissues and facilitating better joint function. To ascertain the statistical significance of these improvements, a paired t-test was conducted on the pre and postoperative functional scores. The results indicated a p-value of 0.005, signifying a statistically significant difference in joint function before and after the procedure, as shown in (Table 4).

Table 4: Joint Function Assessment

Patients (out of 50)	Preoperative MSTS Score	Postoperative MSTS Score	Improvement (%)	p-value
7	20	35	75	0.005
10	18	32	78	
13	22	38	73	
15	21	36	71	
5	19	33	74	

Recurrence monitoring

The meticulous monitoring of recurrence at specific intervals (6, 12, and 18 months postoperatively) has revealed a commendably low recurrence rate of 8%, underscoring the long-term efficacy of Extended Curettage with GCTB around the Knee Joint within the study period from January 2020 to August 2023, details are presented in the following (Table 5). This low recurrence rate can be attributed to several factors. Firstly, the thorough removal of the tumor mass during extensive curettage ensures the elimination of cancerous cells within the targeted region, minimizing the likelihood of recurrence. Secondly, the use of PMMA bone cement in Cementoplasty provides immediate mechanical support, stabilizing the bone structure and preventing the regrowth of tumor cells in the treated area. The targeted approach of localized PMMA application contributes to a confined and effective destruction of cancerous tissue.

The specific monitoring intervals at 6, 12, and 18 months postoperatively allow for timely identification of any potential recurrence, enabling prompt intervention if required. This meticulous tracking not only provides crucial insights into the success of the intervention but also ensures that any recurrence is detected early, facilitating timely and effective management.

Table 5: Recurrence Monitoring at Specific Intervals

No of Patients (n=50)	Time (Months)	Point	Recurrence (Yes/No)	Treatment for Recurrence	Additional Notes
23	6		No	Surgical Excision	Detected at the periphery of the initial lesion.
	12		No		
	18		Yes		
27	18		No		
	12		No		

Discussion

The findings of this retrospective comparative study exploring the outcomes of Extended Curettage with GCTB around the Knee Joint offer valuable insights into the efficacy of the procedure. The comprehensive analysis, spanning a sample size of 50 patients over the research duration from January 2020 to August 2023, provides a nuanced understanding of various aspects, including patient demographics, surgical interventions, local tumor control, joint function, and recurrence rates. The diverse age distribution within the studied cohort, with a significant representation of individuals aged 36 to 45, is particularly notable. This age group constitutes individuals in their prime working years, and the prevalence of GCTB in this demographic emphasizes the need for effective treatment modalities. The gender-balanced representation ensures that outcomes are applicable across genders, enhancing the study's credibility. Surgical interventions, predominantly extensive curettage coupled with PMMA augmentation, demonstrate a preferred and effective approach. The positive correlation between the extent of curettage and postoperative functional outcomes, as indicated by the MSTS score, aligns with established standards. The statistically significant difference in MSTS scores between extensive curettage and PMMA augmentation groups underscores the importance of tailoring interventions for optimal functional outcomes. The observed age distribution, with a substantial representation of individuals aged 36 to 45, aligns with the notion that GCTB commonly affects individuals in their prime working years. The gender-balanced representation enhances the

study's credibility by ensuring applicability across genders. Studies such as Sahito et al. [34] and Gupta et al. [35] have reported similar demographic trends, emphasizing the prevalence of GCTB in adults and the importance of considering both genders in research cohorts.

The preferred surgical interventions, extensive curettage coupled with PMMA augmentation, demonstrate effectiveness in achieving optimal functional outcomes, as indicated by the MSTS score. The positive correlation between the extent of curettage and postoperative functional outcomes aligns with established standards. Research, such as the study by Tsukamoto et al. [12], supports the importance of extensive curettage and PMMA augmentation in achieving favorable functional outcomes. The correlation between surgical interventions and functional results is consistent with the current understanding in the literature.

The remarkable success in local tumor control, with a rate of 92%, affirms the efficacy of Extended Curettage with Cementoplasty. The meticulous removal of tumor mass through extensive curettage, coupled with the immediate mechanical support provided by PMMA bone cement, contributes to containing GCTB within the treated area. The targeted approach of localized PMMA application minimizes collateral damage to healthy tissues, further supporting the success of local tumor control. The observed success in local tumor control, achieving an impressive rate of 92%, aligns with existing literature on surgical interventions for Giant Cell Tumors of Bone (GCTB). Several studies emphasize the importance of thorough curettage in intralesional surgical treatments, as seen in the key role of extended curettage highlighted in the literature [36,37]. The utilization of PMMA for cement augmentation, a common practice in treating GCTB lesions, has been well-established in literature as a procedure of choice, contributing to enhanced outcomes and stability post-curettage [11,35]

While the current study emphasizes the success of local tumor control with a meticulous approach and PMMA augmentation, it's consistent with the broader literature on curettage techniques and cementation. The targeted application of PMMA, minimizing damage to healthy tissues, aligns with the principle of preserving joint function and minimizing complications, a common goal in GCTB treatment strategies [9,34]. Overall, the findings of the current study resonate with established practices, reinforcing the efficacy of Extended Curettage with Cementoplasty in achieving successful local tumor control in GCTB cases.

The substantial improvement of 28% in joint function, particularly highlighted by a remarkable 75% enhancement in the MSTS score, signifies the positive impact of the procedure on crucial aspects like mobility, pain relief, and overall functional capabilities. Factors contributing to this improvement include the thorough removal of the tumor mass during extensive curettage, the mechanical support provided by PMMA bone cement, and the focused impact on the tumor site during Cementoplasty. The statistically significant difference in joint function before and after the procedure, as evidenced by the paired t-test with a p-value of 0.005, adds robustness to these observations.

The substantial improvement in joint function, as evidenced by a 75% enhancement in the MSTS score, aligns with literature on the positive outcomes of surgical interventions for Giant Cell Tumors of Bone (GCTB). Studies, such as the work by Sahito et al. [34], emphasize the importance of extended curettage in achieving optimal functional outcomes. The reduction in recurrence rates associated with advanced curettage techniques, as highlighted by Singaravadivelu et al. [38], correlates with the observed improvement in joint function in the current study. Contrastingly, the observed improvement in joint function contrasts with older studies where recurrence rates were higher, emphasizing the advancements in treatment options over time. Additionally, the use of PMMA bone cement for mechanical support post-curettage, a common practice in the current study, resonates with Gupta et al. findings [35]. The statistically significant difference in joint function, supported by a p-value of 0.005 in the paired t-test, adds statistical robustness to the observed outcomes, reinforcing the significance of these findings.

The low recurrence rate of 8% over specific intervals (6, 12, and 18 months postoperatively) attests to the long-term efficacy of Extended Curettage with Cementoplasty. The thorough removal of tumor mass, immediate mechanical support, and targeted approach contribute to minimizing the likelihood of recurrence. The systematic monitoring allows for timely identification and intervention if

recurrence occurs, emphasizing the importance of postoperative follow-ups. The observed low recurrence rate of 8% at specific intervals (6, 12, and 18 months postoperatively) underscores the long-term efficacy of Extended Curettage with GCTB. Sahito et al. study [34] supports these findings, emphasizing that extended curettage, whether with or without bone allograft, results in comparable functional outcomes for the knee, with no major difference in recurrence incidence.

Contrasting with the historical recurrence rates exceeding 20%, particularly within 18 months postoperatively [34,36], the present study's results suggest a substantial improvement in the management of GCTB. The systematic monitoring approach aligns with previously reported literature, highlighting the importance of postoperative follow-ups in identifying and intervening in cases of recurrence. Notably, the current findings contrast with He et al. [37], where a significant difference in mean recurrence rates was observed between extended curettage (EC) and other surgical treatments.

Limitations and Future Directions

While the study provides valuable insights, limitations exist, including the retrospective nature and potential selection bias. Future research could include prospective studies with larger cohorts and longer follow-up periods to further validate the presented outcomes.

Conclusion

Extended Curettage with Cementoplasty emerges as an effective intervention for GCTB around the Knee Joint, offering favorable outcomes in terms of local tumor control, joint function, and recurrence rates. The multifaceted approach, incorporating extensive curettage and PMMA augmentation, proves to be synergistic, providing a comprehensive solution for patients with GCTB in this specific anatomical region.

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