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Comparison of Clinical Outcomes Between Autologous Cryosurgery Reconstruction and Bone Cement Reconstruction in Osteosarcoma

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ABSTRACT

Background: Osteosarcoma is a primary malignant bone tumor that commonly affects adolescents and young adults. Limb-salvage surgery has become a preferred approach over amputation, with various reconstruction techniques such as autologous cryosurgery and bone cement reconstruction. However, the comparative clinical outcomes of these methods remain a subject of ongoing investigation.
Objective: This study aims to compare the clinical outcomes between autologous cryosurgery reconstruction and bone cement reconstruction in osteosarcoma patients.
Methods: A retrospective cohort study with a post-test only control group design was conducted using medical records of osteosarcoma patients treated at H. Adam Malik Hospital, Medan, from January 2022 to December 2025. A total of 22 patients were included and divided into two groups: cryosurgery (n=11) and bone cement reconstruction (n=11). Clinical outcomes were evaluated using MSTS scores, relapse rates, and metastasis incidence. Statistical analysis was performed using appropriate comparative tests with a significance level of $p<0.05$.
Results: The results showed no statistically significant differences between the two groups in terms of MSTS scores ($p=0.51$), relapse rates ($p=0.06$), and metastasis incidence ($p=0.64$). Although the bone cement group demonstrated slightly higher MSTS scores, the difference was not significant. Similarly, relapse and metastasis rates were comparable between groups.
Conclusion: Autologous cryosurgery and bone cement reconstruction provide comparable functional and oncological outcomes in osteosarcoma patients undergoing limb-salvage surgery. Both methods can be considered viable reconstruction options, with selection tailored to patient condition, resource availability, and clinical considerations. Further studies with larger sample sizes and prospective designs are recommended.

INTRODUCTION

Osteosarcoma is a primary malignant bone tumor with an incidence rate of 20% of total bone tumor cases. Osteosarcoma has a bimodal age distribution. Some of the procedures carried out in osteosarcoma cases include chemotherapy, radiotherapy, and surgical procedures. Surgical procedures show outward good results in the management of osteosarcoma.

Some types of surgical procedures that can be performed include extensive excision, *limb-salvage procedures*, and amputation. In the early 1990s, amputation became the main surgical procedure of choice in osteosarcoma cases. Over time, better chemotherapy has led to the development of different types of surgical procedures. Operational actions *Limb salvage* began to be introduced as an alternative to amputation in treating osteosarcoma. Some studies show the action *limb-salvage* Provides better clinical outcome outcomes compared to amputation in osteosarcoma patients.

Limb-salvage *procedures* aim to reconstruct bone defects after extensive excision in osteosarcoma. There are several *limb-salvage* options available, including: *megaprosthesis*, *cryosurgery* (*liquid nitrogen autologous*

bone), *fibular strut graft*, and *bone cement*. Each type of *limb-salvage* procedure has its advantages and disadvantages. Megaprosthesis is a good choice in performing post-excision reconstruction in osteosarcoma. *Cryosurgery* is one of the reconstruction techniques that is quite popular in developing countries.

This method has the advantage of providing a lower cost than reconstruction procedures using *megaprosthesis*. In addition, *cryosurgery* provides advantages which is a type of biological reconstruction. However, there are still some drawbacks where the effectiveness of *cryosurgery* in terms of relapse and recurrence. There is another option in performing *limb-salvage surgery* reconstruction in osteosarcoma cases is to use *bone cement*. *Bone cement* can be one of the options to replace bone defects after extensive excision in osteosarcoma cases. This reconstruction technique has the advantage that providing *bone cement* provides local chemotherapy, *early weight bearing*, faster surgery duration, and a lower risk of *recurrence compared to cryosurgery*.

RESEARCH METHOD

This study is a retrospective cohort study with *a post-test only control group design.* This research was conducted at H. Adam Malik Hospital, Medan, Indonesia using medical record data of osteosarcoma patients in the period January 2022 – December 2025. The time of the study is from the time the research is approved by the ethics committee and received ethical clearance until the results of the study are presented.

Population, Research Samples, and Sampling Techniques

The population of this study is patients suffering from osteosarcoma. The affordable population is a part of the target population treated at Adam Malik Hospital Medan. The research sample is a part of the target population treated in the period January 2022 – December 2025. Samples will be recruited by non-probability sampling, namely by consecutive sampling technique. Where samples are taken sequentially according to inclusion and exclusion criteria until the minimum sample size is met.

Data Analysis

Data will be analyzed in stages. To determine the frequency distribution based on independent variables, descriptive analysis will be performed. Numerical data are presented in the form of mean and standard deviation or average. Categorical data is presented in the form of percentages. The normality of the data will be tested using the Shapiro-wilk test. The difference in relapse and metastasis values will be assessed using the chi-square test or the fisher exact test. The difference between the MSTS score and the Karnofksy score will be assessed using the unpaired t-test if the data is normally distributed or the Mann U-Whitney test when the data is not normally distributed. Data analysis uses SPSS ver 27.0. All results are declared meaningful with a $p<0.05$ value.

RESEARCH RESULTS

In this study, 8 patients were found with a larger male population compared to women. This result is in accordance with the previous findings where the incidence of osteosarcoma is more found in male patients compared to women. In this study, the average age of patients was found to be 18.73, ± 14.62 where osteosarcoma patients are often found at a young age. The Karnofsky score in this study was found with an average of 70.45±, 7.2. The Enneking score in this study was found with degrees 2A and 2B.

Table 1. Characteristics of research patients

Variable	Cryosurgery (n = 11)	Bone Cement (n = 11)	p-value
Age	12.45 ± 3.7	25.0 ± 18.6	<0.05
Gender (Male) (%)	54	36	0,39
Enneking Score			
2A	9	8	
2B	2	3	0,41
Karnofsky score	73.64 ± 6.7	67.27 ± 6.47	<0.05

In this study, the MSTS score showed no difference in outcome between the bone cement and cryosurgery groups. The incidence of relapse and metastasis in this study also showed no difference between the two groups.

Table 2. Outcomes of MSTS, relapse, and metastasis in both groups

Variable	Cryosurgery (n = 11)	Bone Cement (n = 11)	p-value
MSTS	54.96 ± 5.8	63.0 ± 8.1	0.51
Relapses (%)	45	10	0.06
Metastasis (%)	36	27	0.64

DISCUSSION

Functional Outcomes Based on MSTS Score

The results of this study showed that the MSTS score in the bone cement group was higher than in the cryosurgery group, although the difference was not statistically significant. These findings suggest that in general the two local adjuvant methods are able to provide comparable functional results.

Cryosurgery works through the mechanism of tumor cell destruction with repeated cycles of freezing and thawing that cause cell membrane damage, protein denaturation, as well as local microcirculation disruption.[40] This technique allows for the preservation of the bone matrix and provides biomechanical advantages that can contribute to better limb function.[41]

In contrast, the use of bone cement provides immediate mechanical stability and cytotoxic effects due to the heat generated during the polymerization process, which can help eliminate residual tumor cells. However, the mechanical properties of bone cement that are more rigid than real bone have the potential to affect load distribution and limb function in the long run.

The absence of statistically significant differences in this study may be due to differences in the stages of Enneking between groups can also affect the functional results obtained.

Oncological Outcomes: Relapse and Metastasis

The incidence of relapse and metastasis in this study did not show a significant difference between the bone cement and cryosurgery groups. This shows that the two local adjuvant methods have relatively equal effectiveness in oncological disease control.

The success of local control in osteosarcoma is strongly influenced by the adequacy of the surgical resection margin and response to neoadjuvant chemotherapy, in addition to the type of local adjuvant used.[36,42] Cryosurgery and bone cement both provide local cytotoxic effects that can help lower the risk of residual tumor cells after surgery.

Although the metastasis rate appears to be higher in the cryosurgery group, the difference is not statistically significant. This is likely related to the greater proportion of stage 2B in the cryosurgery group, given that the later stages have a higher risk of metastasis.[43]

Research Limitations

This study has several limitations that need to be considered in the interpretation of the results. First, the number of samples in this study is relatively small, so the statistical power to detect small but clinically significant differences between the cryosurgery and bone cement groups is limited. This condition also increases the likelihood of type II errors.

Second, observational and retrospective research designs have the potential to cause selection bias. The selection of reconstruction methods is not random, so there is a possibility of differences in basic characteristics of patients between groups, such as age and Karnofsky scores, which can affect functional and oncological outcomes. Third, this study did not evaluate other factors that could affect outcomes, such as tumor size, specific anatomical location, response to neoadjuvant chemotherapy, and adherence to postoperative rehabilitation programs. These factors have the potential to be confounding variables that affect MSTS, relapse, and metastasis score outcomes.

Fourth, the duration of follow-up in this study is relatively limited, so the possibility of long-term relapse or metastasis cannot be optimally evaluated. Therefore, the oncological results obtained in this study are more reflective of short-term to medium-term outcomes.

Clinical Implications

Despite its limitations, the results of this study provide important clinical implications. The absence of significant differences in MSTS scores, relapse rates, and metastasis suggests that cryosurgery and bone cement can be considered as equivalent reconstruction options in osteosarcoma patients with comparable tumor characteristics.

The selection of reconstruction methods in clinical practice can be adjusted to the patient's condition, the availability of facilities, the operator's experience, as well as the consideration of cost and operating time. In service centers with limited complex reconstruction facilities, cryosurgery and bone cement can be a rational alternative without sacrificing functional and oncological outcomes.

In addition, differences in initial Karnofsky scores between groups emphasize the importance of a thorough evaluation of the patient's functional condition before action, as early functional status can affect postoperative outcomes and the rehabilitation process.

Conclusion

Based on the results of this study, it can be concluded that the use of bone cement and cryosurgery as local adjuvant in limb salvage procedures in osteosarcoma patients provides relatively comparable functional and oncological outcomes. Cryosurgery shows a tendency for better functional outcomes, but further research with larger sample counts and prospective designs is needed to confirm these findings.

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