

The Efficacy of Limb Preservation Surgeries after Osteosarcoma Removal Compared to Amputations



Aashka Shah

Medical Science Internship Program 2021

Virginia Commonwealth University School of Medicine

Abstract

Osteosarcoma is the most common primary bone malignancy and the third most common cancer in adolescents. A majority of osteosarcoma cases were treated with amputations in the past in order to prevent reoccurrence; however, as surgical techniques and specifically diagnosis and treatment of osteosarcomas have advanced in the 21st century, limb preservation or limb salvage surgeries have become the standard. These advances have made it possible for osteosarcoma patients to keep their limbs while preventing recurrence. Techniques for limb preservation surgery in osteosarcoma removal, such as tumor endoprostheses, allograft reconstruction, and expandable prosthesis are not well-researched in their current early stages and must be evaluated further to better understand the disease and make optimal treatment decisions. This review will evaluate existing literature for these various techniques in regard to post-surgical outcomes including metastasis/recurrence, mortality, and infection to elucidate which techniques may provide optimal treatment outcomes. Tumor endoprostheses, allograft reconstruction, and expandable prosthesis were found to be equally effective if not more at treating osteosarcomas in terms of preventing recurrence and metastasis. While limb preservation surgeries often require more maintenance such as correction surgeries and outgrowing implants, they allowed patients the physical and psychological benefits of keeping their limbs. Additionally, the survival time for limb preservation surgeries was greater than that of amputations as the 5-year survival rate was 70.7% compared to the 55.3% rate for amputations. Further studying the efficiency of these techniques is necessary to improve outcomes after osteosarcoma treatment and make optimal treatment decisions.

Introduction

Osteosarcoma is an incredibly aggressive cancer of the bone. Receiving an osteosarcoma diagnosis in the past was nearly always fatal; however, advances in neoadjuvant chemotherapy have greatly improved the survival rates of these cancer patients. As a result, many doctors believe amputations are no longer necessary to contain this incredibly deadly and fast-spreading disease. The National Institute of Health even stated that limb salvage surgeries were equally as effective as amputations.

While amputations have high rates of success in helping prevent osteosarcoma recurrence, metastasis, and mortality, they have many negative consequences. Complications that often occur after amputation include heart problems, deep vein thrombosis, infections in the wound, slow wound healing, pneumonia, and pain that seems to be coming from the amputated limb, which is known as phantom limb pain. Additionally, losing a limb is detrimental to many patient's mental health as it can cause body image issues and loss of function. In order to avoid the many complications with amputations, limb salvage surgeries are utilized. Only the tumor and the areas surrounding the tumor are removed in tumor salvage surgeries compared to the entire limb in amputations.

Three common examples of limb salvage surgeries include...

- Tumor Endoprostheses
- Allograft Reconstruction
- Expandable Prosthesis

Images

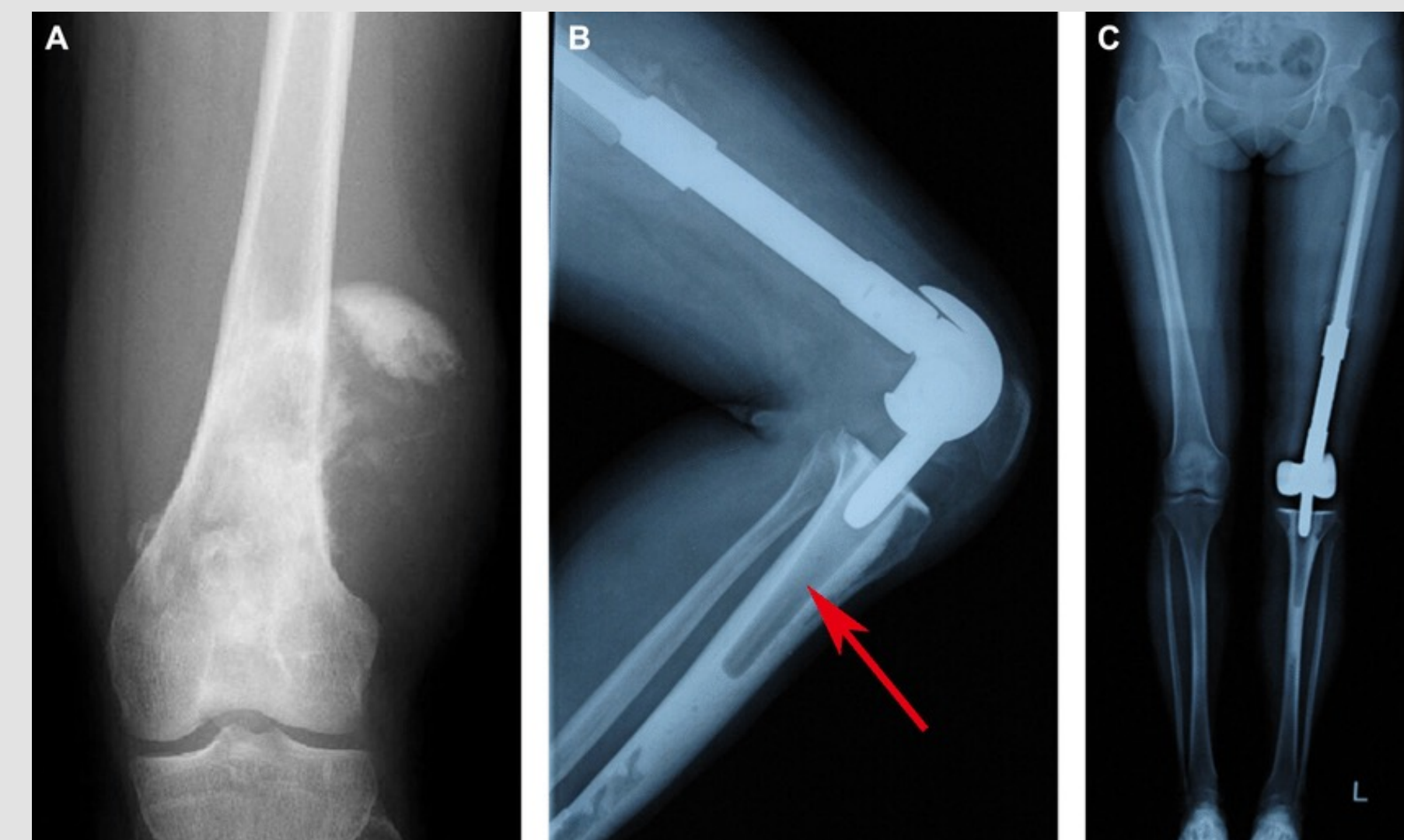


Figure 1: X-ray images of an osteosarcoma patient whose left distal femur tumor was treated with an all-polyethylene tibial endoprosthesis replacement. Image A: preoperative AP view of knee; Image B: postoperative lateral view of knee in flexion; Image C: postoperative lower extremity view. A tumor endoprosthesis replaces the missing body part inside of the patient's body.



Figure 2: X-ray images of an 11-year-old boy with stage IIB osteosarcoma at the distal third of the femur who was treated with a massive allograft reconstruction after resection of the tumor. Image A: anteroposterior view; Image B: lateral view; Image C: 6 months postoperative view of the femur; Image D: 1-year postoperative view of the femur. An allograft reconstruction consists of using tissues obtained from a donor for reconstruction.

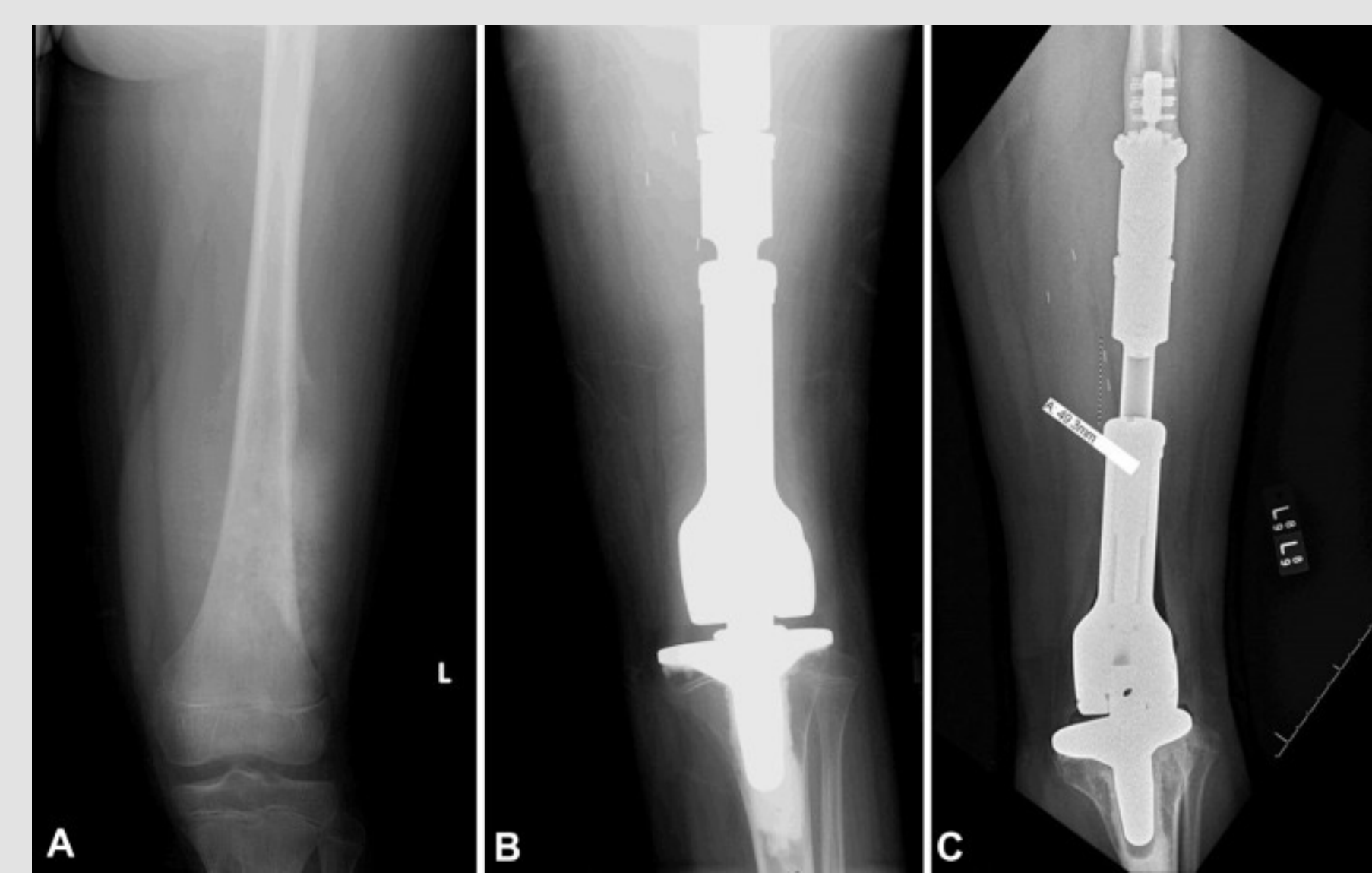


Figure 3: X-ray images of a 11-year-old male patient whose distal femur was reconstructed using an expandable endoprosthesis after osteosarcoma removal. Image A: preoperative view of the femur; Image B: immediate postoperative view; Image C: 2-year postoperative view. An expandable endoprosthesis is a special type of endoprosthesis that replaces a missing body part inside of the body with a device that can automatically expand. The various expansion mechanisms inside the device allow it to elongate without additional surgeries making the procedure perfect for growing children.

Results

In a study with 3363 osteosarcoma patients, 2447 received limb salvage surgeries while the remaining 916 underwent amputations. The 3-year survival rate for limb salvage surgeries was 78.9% and the 5-year was 70.7%, and for amputations, the 3-year was 64.5% and the 5-year was 55.3%. Limb salvage patients had significantly higher survival percentages.

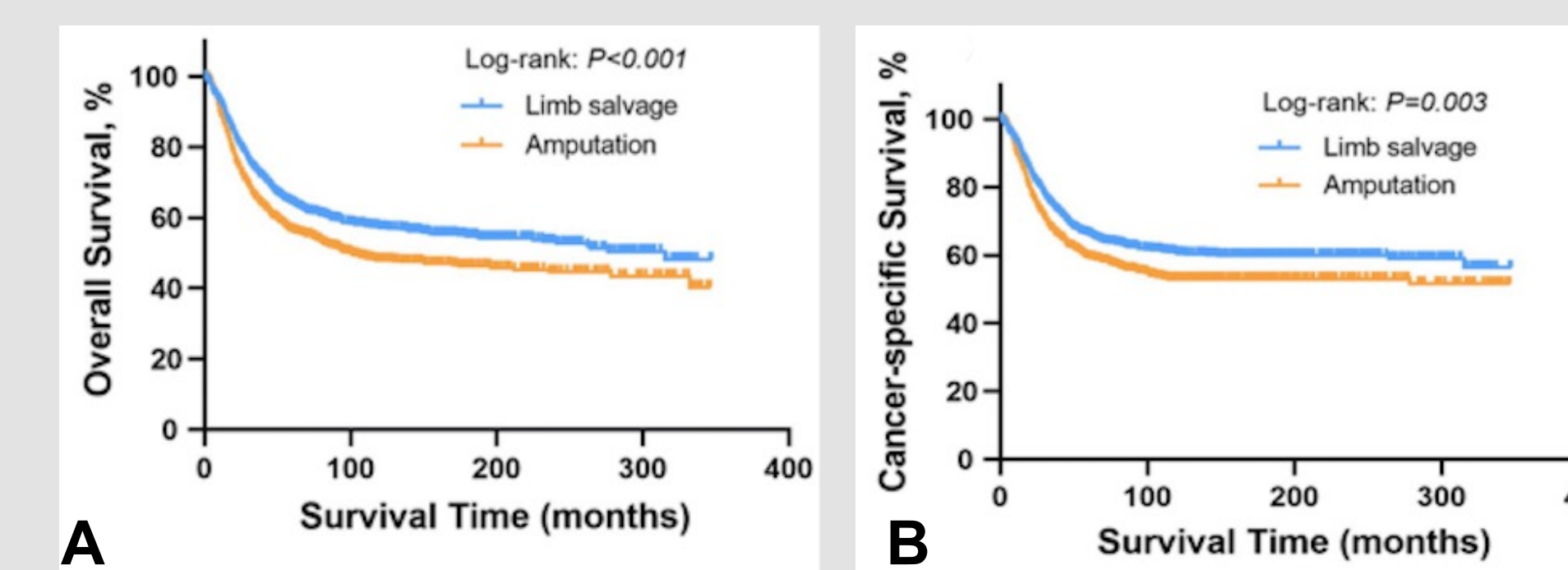


Figure 4: Kaplan-Meier Survival Curves comparing patients who received limb salvage surgeries and patients who received amputations. Graph A: Overall Survival Data; Graph B: Cancer-Specific Survival Data

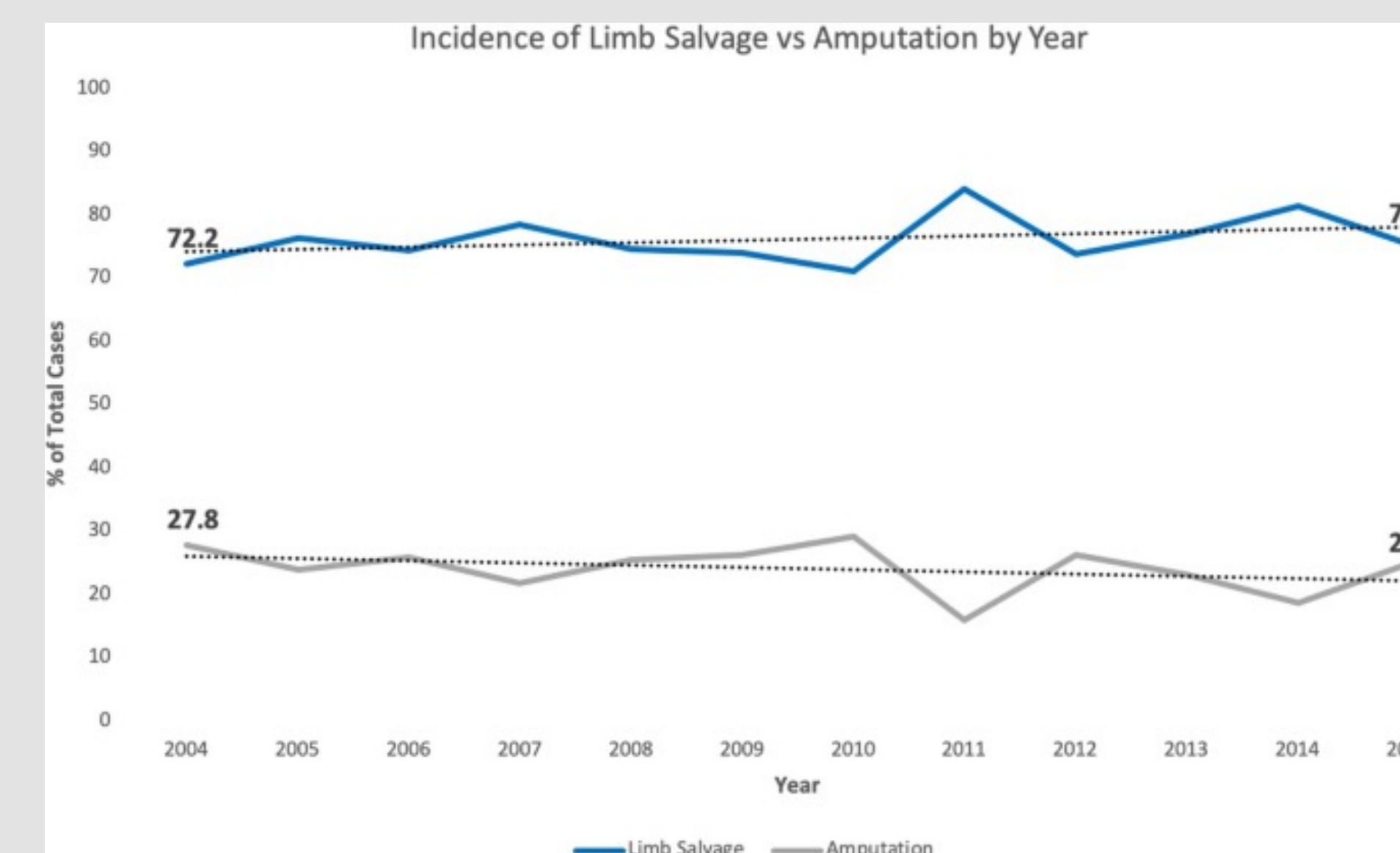


Figure 5: Incidence of Limb Salvage versus Amputation over time Graph

Limb Preservation Surgery	Information
Tumor Endoprostheses	<ul style="list-style-type: none"> • The European PMC found that of 78 patients who were treated with endoprostheses, the local recurrence rate was 5%, the rate of infection was 3%, and 28 of the 78 patients experienced a total of 30 complications • Scientific Reports found that of 11 tumor endoprostheses patients, 22% had at least one complication
Allograft Reconstruction	<ul style="list-style-type: none"> • After primary surgery, 74% of the patients were healthy with no major complications, and 83% of the patients reported good results after secondary surgery in 112 bone allograft reconstructions according to Clinical Orthopedics and Related Research • Of 15 patients, the disease-free survival rate for 5 years was 73.3% in the International Journal of Surgery for allograft reconstructions
Expandable Prosthesis	<ul style="list-style-type: none"> • The Journal of Orthopedic Surgery conducted a study on 20 patients with expandable prosthesis and found a 5-year mortality rate of 10%, a 15% rate of infection or implant failure, and an overall survival rate of 90% • The Pediatric Blood and Cancer Journal found an average follow-up of 61.7 months, a 2 years and 8 months average survival time for device, and 12 total complications for the 17 patients studied

Conclusion

In terms of mortality, limb preservation surgeries showed promise as they provided significantly longer survival times. Additionally, both amputations and limb salvage surgeries were successful in preventing reoccurrence of the former malignancy and metastasis. Further research on perioperative complications is needed, though current findings may suggest that tumor endoprosthesis shows lower infection rates compared to expandable prosthesis. In conclusion, limb preservation surgeries are efficacious techniques for treatment of osteosarcoma and lead to longer survival times than amputations, though further research is needed to compare complication rates.

Future Directions

One possible confounder in this study was the demographics of amputation patients tends to be in lower economic classes and in worse living conditions compared to limb salvage surgery patients potentially contributing to the worse outcomes for amputees. Research on the socioeconomic status of osteosarcoma patients may help elucidate obstacles they may have and how they relate to treatment outcomes. Further research into other limb preservation surgeries and other factors such as cost, maintenance, complications, and patient demographics would provide valuable insight in understanding osteosarcomas.

References

Aponte-tinao, L., Ayerza, M. A., Muscolo, L. D., & Farfalli, G. L. (2015). Survival, recurrence, and function after epiphyseal preservation and allograft reconstruction in osteosarcoma of the knee. *Clinical Orthopaedics & Related Research*, 473(5), 1789-1796. <https://doi.org/10.1007/s11999-014-028-5>

Böhler, C., Brönimann, S., Kaider, A., Puchner, S. E., Sigmund, I. K., Windhager, R., & Funovics, P. T. (2018). Surgical and functional outcome after endoprosthetic reconstruction in patients with osteosarcoma of the humerus. *Scientific Reports*, 8(1). <https://doi.org/10.1038/s41598-018-34397-5>

Evans, D. R., Lazarides, A. L., Visgauss, J. D., Somarelli, J. A., Blazer, D. G., Brigman, B. E., & Eward, W. C. (2020). Limb salvage versus amputation in patients with osteosarcoma of the extremities: An update in the modern era using the national cancer database. *BMC Cancer*, 20(1). <https://doi.org/10.1186/s12885-020-07502-z>

Qi, L., Ren, X., Liu, Z., Li, S., Zhang, W., Chen, R., Chen, C., Tu, C., & Li, Z. (2020). Predictors and survival of patients with osteosarcoma after limb salvage versus amputation: A population-based analysis with propensity score matching. *World Journal of Surgery*, 44(7), 2201-2210. <https://doi.org/10.1007/s00268-020-05471-9>

Acknowledgements

- I would like to thank my mentor Viraj Sharma for his guidance throughout the research process
- I would like to thank the co-directors of the VCU Medical Sciences Internship Program Yumna Rahman, Martina Abuphillipous, and Siddharth Venigalla for organizing this program and their lessons on research
- I would like to thank Dr. Michelle Whitehurst-Cook for sponsoring this program