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Long-Term Results Of Joint-Preserving Surgery In Paediatric Leg Sarcoma Using 3D Digital Planning And Navigation/3D-Printed Resection Guides

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Abstract

1 Introduction

Joint-preserving tumor resection and patient-specific implant (PSI) reconstruction have the advantages of retaining the function and growth of native joints. Long-term complications of PSI in young active patients were a concern [1]. 3D planning and assistive tools like Navigation (NAVI) or 3D-printed guides (PSG) may facilitate the technically demanding surgical procedures [2,3] as it is challenging to translate the surgical plan with a negative surgical margin and match it to the PSI.

2 Methods

We treated 20 paediatric and adolescent patients with lower extremity bone sarcoma who underwent joint-preserving tumor resection and extendable PSI (2006 and 2019). The mean age was 11 (5-17). Engineers designed PSI and PSG based on surgeons' defined surgical planning in MIMICS (version 16, Materialise, Belgium). After neoadjuvant chemotherapy, surgeries were assisted with 12 NAVI (Stryker), 4 PSG, or a combination (4 NAVIG) (Figure 1).

Oncological results and limb functions were recorded. Patient overall disease survival and PSI survival with revision surgery as endpoint were calculated using Kaplan-Meier method (R Core Team (2023).

3 Results

With a mean follow-up of 9.9 years (4.7 -17.7), three patients died from disease progression, and one patient defaulted follow-up. Using Kaplan-Meier, patient survival was 90% and 81.8% at five and ten years (Figure 2A). PSI survival was 94.1% and 86.9% at five and ten years (Figure 2B). There was one Henderson Type II aseptic loosening and two Type III structural failures that required major implant components to be revised. MSTS score was 29.2 out of 30 (28-30). Surgical margins were all negative in bone except one soft tissue positive margin. All PSIs matched well to the retained articular bones intraoperatively and showed osseointegration at PSI junctions except one and continuous joint growth postoperatively.

4 Discussion and Conclusion

The long-term results suggested that with 3D planning and tools like NAVI and PSG, technically demanding joint-preserving surgeries could be accurately implemented as planned with excellent limb and joint function without compromising oncological results [4]. The computer-assisted approach might minimize soft tissue detachment by retaining the blood supply to the small articular bone segments. Osseointegration at the well-matched PSI junction suggested stable primary fixation and secondary healing of the PSI [5]. More cases and comparisons with conventional joint-sacrificing surgery were needed.

5 References

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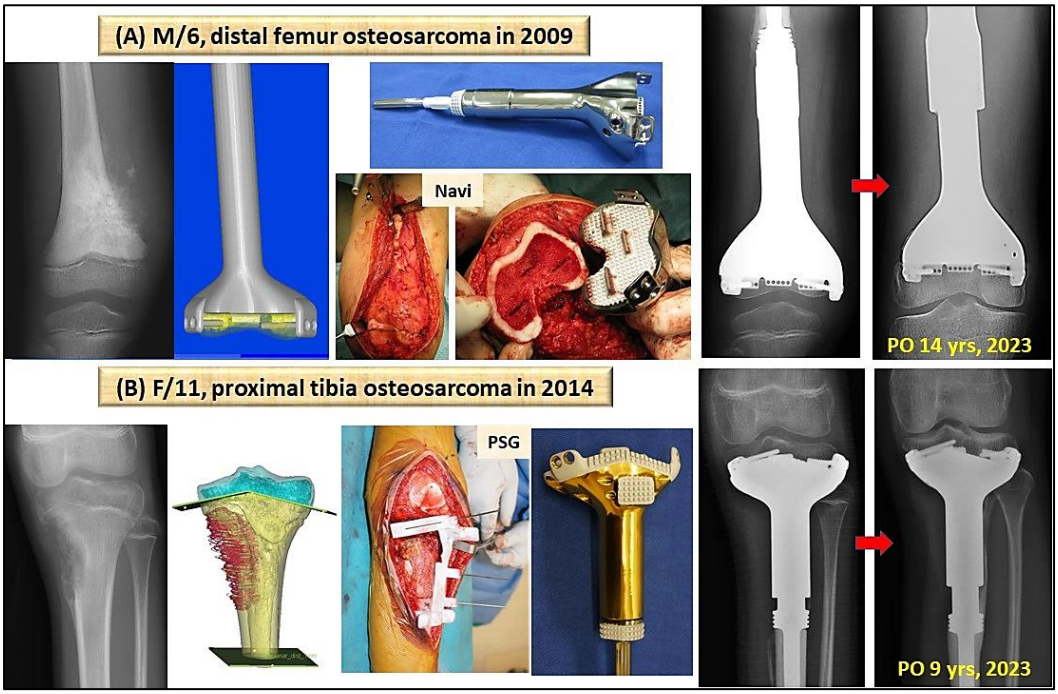

Figure 1: (A) A six-year-old boy with right distal femur osteosarcoma underwent navigation-assisted joint-preserving tumor resection and reconstruction with an extendable patient-specific implant in 2009. (B) an eleven-year-old girl with left proximal tibia osteosarcoma underwent 3D-printed guide-assisted biplanar tumor resection and reconstruction with an extendable patient-specific implant in 2014. The long-term follow-up shows continuous growth of retained articular bone and knee joint.

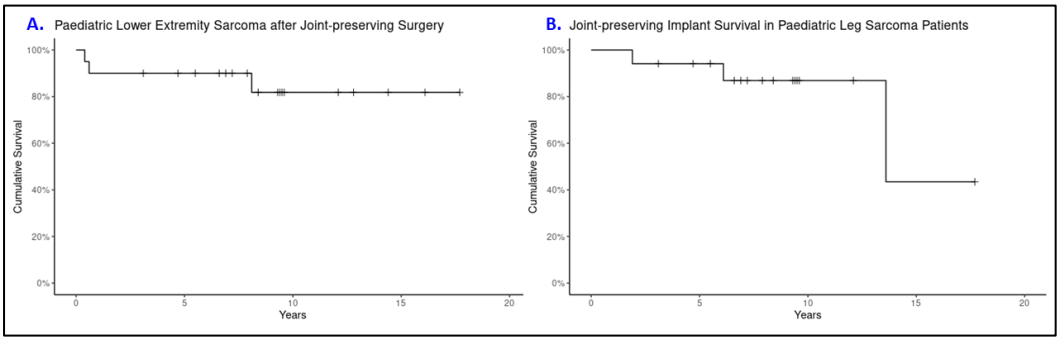

Figure 2. Kaplan-Meier curves of Paediatric lower extremity sarcoma after joint-preserving surgery for overall survival (A) and implant survival with revision surgery as the endpoint (B).