The most common locations for bone sarcomas in children are the distal femur and proximal tibia. The epiphyses of the distal femur and proximal tibia contribute approximately 35% and 30%, respectively, to growth of the lower extremity. Therefore, resection of the physis will result in leg-length discrepancy at skeletal maturity, functional deficit, gait disturbances, and cosmetic issues.

Until the 1970s, amputation was the main treatment for bone sarcomas in children. Thereafter, advances in medical treatments, imaging, surgical techniques, and biomedical engineering have revolutionized the management and survival rates of children with bone sarcomas. Currently, 85% of children undergo limb-salvage surgery using allografts, vascularized bone transfer, bone transport, and megaprostheses. Megaprosthetic reconstructions for tumor surgery were introduced in the 1970s. Adult-type megaprostheses can be used for children who are near skeletal maturity. If the resection of the physis is expected to result in a limb-length discrepancy of <30 mm, the limb can be lengthened by 10 to 20 mm during the reconstruction, leaving an acceptable leg-length discrepancy at the completion of growth. If the anticipated leg-length discrepancy is >30 mm, alternative reconstructions should be used.

Currently, several manufacturers offer expandable implants, which are desirable for younger, skeletally immature patients with long expected growth. First-generation expandable megaprostheses appeared in the late 1970s. They were invasive, and open surgery was necessary to perform the elongation. In 1976, the Centre for Biomedical Engineering manufactured the first expandable implant that used a simple worm drive mechanism to extend the prosthesis. In 1983, the Lewis Expandable Adjustable Prosthesis (Dow Corning Wright Corporation, Arlington, Tennessee) was introduced. It used a fixed stem with a screw extension mechanism that expanded the prosthesis.

Second-generation expandable megaprostheses were minimally invasive; lengthening was achieved with an elongating screw or a telescopic mechanism. Although they also required an open procedure, the need for soft tissue dissection was dramatically reduced. In 1987, the minimally invasive Growing Kotz prosthesis was introduced; it included a growth module that matched the Kotz Modular Femur and Tibia Reconstruction system (Stryker Howmedica Osteonics, Rutherford, New Jersey) and its successors, the fixed-hinge Howmedica Modular Resection System and the rotating-hinge Global Modular Replacement System (Stryker Howmedica Osteonics). The growth module had an encapsulated elongation mechanism containing a threaded spindle driven by a bevel gear pair that moved a titanium sleeve by a threaded bush. When growth had ceased, the extendable module could be replaced by the components of the respective adult-type prosthesis.

In the early 1990s, Biomet Corporation (Warsaw, Indiana) developed a more rigid extendable module using a mechanically controlled telescoping device. Once extension was achieved, metallic blocks were placed in the telescoping pieces to hold them at the appropriate length. The Stanmore minimally invasive expandable prosthesis (Stanmore Implants, Stanmore, Middlesex,
United Kingdom) was a good option for patients reaching skeletal maturity, especially if the resection was relatively small. Once growth had ceased, the implant could be retained.\textsuperscript{10,11}

Third-generation expandable prostheses were non invasive; lengthening was achieved without open surgery, and the risk of complications due to repeated surgeries was minimized.\textsuperscript{6,10,12,13} In 1984, the Repiphysis non invasive expandable prosthesis (Wright Medical Technology, Inc, Arlington, Tennessee), originally known as the Phenix Prosthesis (Phenix Medical, Paris, France), was developed.\textsuperscript{13} The prosthesis consisted of 2 tubes and 1 spring buried in the larger tube, which was kept compressed by a polyethylene locking mechanism. Expansion was achieved via exposure to an external electromagnetic field that heated an antenna within the implant. The heated element softened the surrounding polyethylene locking mechanism, allowing for the spring expansion that pushed the 2 tubes apart from each other.\textsuperscript{6,13,14}

The Stanmore non invasive expandable prosthesis (Stanmore Implants) used an electric current to produce a rotating magnetic field that was captured by a magnet within the implant and extended a gearbox.\textsuperscript{9,10} The bioexpandable MUTARS BioXpand prosthesis (Implantcast, Buxtehude, Germany) was introduced in 2005.\textsuperscript{4} Based on the method of callus distraction, this system used a lengthening nail as a modular part of the prosthesis to activate bone growth and lengthen the remaining bone. Lengthening was activated by a high-frequency transmission from outside the skin. The joint-forming part did not differ from conventional tumor prostheses. After growth ceased, the expandable components could be replaced by the adult-type MUTARS components.\textsuperscript{4,15}

Total lengthening ranging from 4.25 to 55 mm and good or excellent (>70%) Musculoskeletal Tumor Society function have been reported with expandable prostheses in children at 12- to 152-month follow-up.\textsuperscript{6,16-18} However, a high failure rate has been reported with first-generation expandable prostheses; implant survival to revision or amputation was 93.9% at 1 year and decreased to 65.2% at 5 years and 0% at 10 years.\textsuperscript{9} Open lengthening procedures for first- and second-generation designs were accompanied by the risk of ankylosis, nerve damage, and infection.\textsuperscript{7,9} Third-generation expandable prostheses have shown promising early results, but additional data about their long-term structural integrity are required.

With the available data, approximately 25% of expandable prostheses needed to be revised for complications over the first 5 years, the overall risk of developing at least 1 complication increased to 82% at 10 years, and some designs have been associated with a higher inherent risk of complications.\textsuperscript{6,9,11-13,16,17,19-21} Aseptic loosening and metal fatigue, mechanical dysfunction and failure, soft tissue contractures, adjacent physis injury, dislocation, and infection were the most common complications.\textsuperscript{9,11-13,16,17,20,21} The moving parts of the prostheses were subjected to extensive wear, resulting in failures of the expanding mechanism, implant breakage, breakage of the clips holding the telescoping device, and failure of the plastic material in the all-polyethylene devices.\textsuperscript{6,11} The development of a black-stained pseudocapsule surrounding prostheses predominantly made of titanium has been reported.\textsuperscript{7,12} The infection rate, most commonly for proximal tibia reconstructions, ranges from 25% to 40%.\textsuperscript{12} The overall risk of the prosthesis becoming infected was 68% within 10 years; the risk of infection per procedure was 5.1%.\textsuperscript{9,19} Neurovascular compromise was minimal if lengthening was ≤2 cm. Wound complications reduced with minimally invasive or non invasive lengthening procedures. Joint stiffness was avoided with small lengthening of 6 to 10 mm per procedure, rehabilitation, and avoidance of further lengthening for at least 6 weeks if stiffness occurred.\textsuperscript{5}

Currently, expandable prostheses are worthwhile as spacers to maintain equal limb length and a functional limb until skeletal maturity is achieved. However, they are still under development. Because the primary goal of treatment is to remove the tumor, alternative reconstruction options or amputative techniques and rotationplasty should be considered.

\textbf{REFERENCES}


