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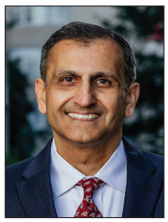
Evolution of Tibial Lengthening Techniques: Two Steps Forward, One Step Back?



The methods of performing a percutaneous osteotomy for distraction osteogenesis have been well established. While Ilizarov's principles of optimizing new bone formation[1] have stood the test of time, issues such as pin-tract infections, transfixation of musculotendinous units, and psychosocial limitations imposed on the patient due to prolonged use of an external device have led some surgeons to try new techniques and devices. Some of these methods for limb lengthening, such as lengthening over nail (LON)[2] and lengthening and then nailing (LATN),[3] still involve the use of an external fixator, albeit for a much shorter period, and have additional advantages such as safeguarding the lengthened regenerate with an intramedullary nail. More recently available motorized implantable lengthening nail (MILN) has been a disruptive technology, allowing patients to achieve lengthening of bone segments without long-term external fixation. However, robust head-to-head comparative studies evaluating the efficacy of bone formation and prevalence of unique complications among the currently available techniques for tibial lengthening are lacking.

In this issue of JLLR, Fragomen *et al*. sought to answer this, using a cohort of their adult patients undergoing tibial lengthening for assorted indications. Despite the methodologic concerns such as a retrospective study design, heterogeneity among different treatment groups, nonconcurrent surgical grouping, and possibility of measurement bias for assessing bone healing, the authors have done a commendable job in culling through their data and reporting their findings in a clear fashion. In the hands of two experienced limb-lengthening surgeons, the Bone Healing Index was substantially less, i.e., better for patients undergoing LATN group (0.8 months/cm) than the more recently adopted MILN (1.5 months/cm) or the classic hexapod external fixation (1.9 months/cm). Interestingly, nearly one-third (8/27) of the tibias in the MILN cohort additionally received a prophylactic injection of bone marrow aspirate concentrate into the regenerate to enhance bone formation, a supplemental treatment not administered to the other two treatment groups. The authors postulate that the faster bone healing noted in the LATN group may be related to a few unique attributes of this intermediary technique, including the enhanced periosteal vascularity and autografting associated with reaming through a lengthening regenerate, a more metaphyseal location of osteotomy, and a slightly larger amount of lengthening than with the MILN patients in this group of patients. In an earlier study, comparing bone formation through the distraction phase of tibial lengthening for familial short-stature adults using LON versus LATN, Ryu *et al*.[4] reported more robust bone regeneration in the LATN patients. They suggested that the timing of intramedullary reaming for tibial lengthening may have an impact on the quality of lengthening regenerate, with better healing response noted if reaming was carried out at the end rather than at the beginning of the distraction period. Furthermore, in the current study, the authors found no clear advantage in terms of preservation of joint mobility with MILN compared to the other two techniques utilizing external fixation. While this report certainly gives one a reason to pause before abandoning previous tibial lengthening techniques, the jury is still out.

In another article, Herzenberg and his team of proficient limb lengtheners took this to the next level. They reported on acute fixator-assisted deformity correction followed by lengthening using an MILN in 22 segments (12 femurs and 10 tibias), in patients who had both, limb deformity and ipsilateral shortening. This technique was used in 17% of their Precice™ lengthening patients over the 3-year study period. They were justifiably quite selective in their indications, and for the most part restricted this technique to those individuals with <15° of deformity. Although not achieving statistical significance (likely related to small sample size), they reported a substantial difference in the Consolidation Index (CI) between the femur (33.8 days/cm) and the tibia (51.6 days/cm). What makes this slower healing of the tibia especially concerning is that this occurred despite a longer latency period (7 vs. 5 days) and slower distraction rate (0.75 mm/day vs. 1 mm/day) than used for the femur and the fact that a healed fibula was considered a "tibial cortex" when calculating the tibial CI. Could an even longer latency and slower or more frequent lengthening regimen enhance healing of the tibial distraction callus? Or is MILN a technology that needs to be perfected in the femur before it is fully applied to the tibia? On a related note, while there is no question that the internal lengthening technology and applications are impressive and will continue to evolve, one also needs to find means of making such implants affordable and available to the surgeons practicing in resource-limited environments. For instance, the SIGN™ nail has been an

effective and innovative advancement in intramedullary fixation of long-bone fractures, that is available to a larger segment of the world population at an affordable cost.[5]

As we know, the femur and tibia are quite different when it comes to the limb-lengthening journey. Given the larger soft-tissue envelope around the thigh, adopting MILN for femoral lengthening has certainly been a huge step forward,[6,7] both in terms of patient experience and clinical outcome measures such as minimizing postlengthening fractures and preserving knee motion. As for the tibia, the story may be a bit different. Given the subcutaneous nature of this two-bone lower leg segment, surrounded by a more constrained soft-tissue envelope, bone formation seems to be less robust with MILN, and there may be other unique challenges related to reaming an intact bone prior to distraction osteogenesis. Perhaps, one needs to revisit the LON literature to learn some important lessons. Nevertheless, the authors of these two important studies have certainly set the stage for a larger, prospective, multicenter trial with validated outcome measures, not only including the traditional radiographic and clinical parameters, but also incorporating patient-reported outcome measures and cost analysis, comparing the classic, hybrid, and fully implantable lengthening techniques for the short and crooked tibia. Till then, it is still a dance with two steps forward and perhaps one step back.

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