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Restoring Total Form and Function in Patients with Lower Limb Bony Defects Utilizing Patient-Specific Fused Deposition Modelling- A Neoteric Multidisciplinary Reconstructive Approach

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Abstract : Introduction: The importance of the amalgamation of technological and engineering advances with surgical principles of reconstruction cannot be overemphasized. With earlier detection of cancer, consequences of high-speed living and neglect, like traumatic injuries and infection, resulting in increasingly younger patients with bone defects. This may result in malformations and suboptimal function that is more noticeable and palpable in the younger, active demographic. Our team proposes a technique that encapsulates a mesh of multidisciplinary effort, tissue engineering and reconstructive principles. Methods/Materials: Our patient was a young competitive footballer in his early 30s who was diagnosed with submandibular adenoid cystic carcinoma with bony involvement. He was thus counselled for a right hemi mandibulectomy, the floor of mouth resection, right selective neck dissection, tracheostomy, and free fibular flap reconstruction of his mandible and required post-operative radiotherapy. Being young and in his prime sportsman years, he was unable to accept the morbidities associated with using his fibula to reconstruct his mandible despite it being the gold standard reconstructive option. The fibula is an ideal vascularized bone flap because it's reliable and easily shaped with relatively minimal impact on functional outcomes. The fibula contributes to 30% of weightbearing and is the attachment for the lateral compartment muscles; it is stronger in footballers concerning lateral bending. When harvesting the fibula, the distal 6-8cm and up to 10% of the total length is preserved to maintain the ankle's stability, thus, minimizing the impact on daily activities. There are studies that have noted gait variability post-operatively. Therefore, returning to a premorbid competitive level may be doubtful. To improve his functional outcomes, the decision was made to try and restore the fibula's form and function. Using the concept of Fused Deposition Modelling (FDM), our team comprising of Plastics, Otolaryngology, Orthopedics and Radiology, worked with Osteopore to design a 3D bioresorbable implant to regenerate the fibula defect (14.5cm). Bone marrow was harvested via reaming the contralateral hip prior to the wide resection. 30mls of his blood was obtained for extracting platelet rich plasma. These were packed into the Osteopore 3D-printed bone scaffold. This was then secured into the fibula defect with titanium plates and screws. The flexor hallucis longus and soleus were anchored along the construct and intraosseous membrane, done in a single setting. Results: He was reviewed closely as an outpatient over 10 months post operatively. He reported no discernable loss or difference in ankle function. He is satisfied and back in training and our team has video and photographs that substantiate his progress. Conclusion: FDM allows regeneration of long bone defects. However, we aimed to also restore his eversion and inversion that is imperative for footballers and hence reattached his previously dissected muscles along the length of the Osteopore implant. We believe that the reattachment of the muscle stabilizes not only the construct but allows optimum muscle tensioning when moving his ankle. This is a simple but effective technique in restoring complete function and form in a young patient whose minute muscle control is imperative to life.

Keywords : fused deposition modelling, functional reconstruction, lower limb bony defects, regenerative surgery, 3D printing, tissue engineering
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