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Treatment of Congenital Talipes Equinovarus with Computer Modelling and 3D Printed Orthosis

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Abstract: *Congenital talipes equinovarus (CTEV) is a commonmusculoskeletal condition in newborns, affecting one-to-two perthousand babies. The Ponseti method is a treatment regime forthe management of CTEV which describes a detailed method ofmanipulation, casting and bracing. This popular method was first published in 1963, it only started to become popular in the 1990s.[1] Since then, the common material used for Ponseti cast is Plaster of Paris. This paper demonstrates a modern modification to the aged Ponseti method, with the incorporation of 3D technology and 3D printing method.*

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I. Introduction

Congenital talipes equinovarus (CTEV) is treated surgically or non-surgically.The usual non-surgical methods include Ponseti method, CTEV shoes, Mitchell brace and Dennis Brown splint. Ponseti method is the most general and recognized treatment with a high success rate of over 90%.[2,3] The treatment involves gentle manipulation and serial casting.The rate of success of the Ponseti method is very much dependent on the casting techniques. the Ponseti corrective technique should follow the sequences of cavus, adductus, varus and equinos (CAVE).[4,5,6]

II. Methodology

A 7-month old boy under follow up of Department of Orthopaedics at Hospital Sultan Haji Ahmad Shah, Malaysia, has structural CTEV of right lower limb. This patient was previously treated with percutaneous Achilles tenotomy in January 2019, however he still has residual CTEV which can be corrected with Ponsetti method.

After written informed consent was obtained,Patient's lower limbs are marked with coordination stickers which have measurement points. A series of high resolution photographs of the lower limbs are taken. These photos are processed with a 3D photogrammetry software to produce an exact 3D replica of the lower limbs. The CTEV orthosis is modelled based on patient's anatomy. The orthosis design is then printed with a 3D printer with the bioplastic Polylactic Acid (PLA). The printing process (rapid prototyping) takes approximately 3 hours. Produced via fused deposition modeling of additive manufacturing (AM) technology with PLA (polylactic acid). PLA is a bioplastic, produced from renewable sources, such as corn, sugarcane and beets. This material is more environmental friendly, unlike other thermoplastics which are petroleum-based.

Fig-1: The right leg with CTEV is marked with measuring tapes, and photos from multiple angles are taken.

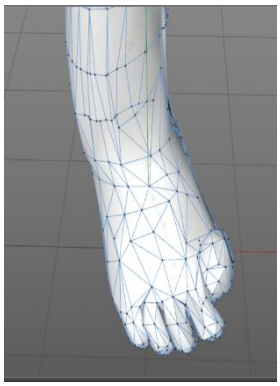

Fig-2: A computer model of the affected leg is generated.

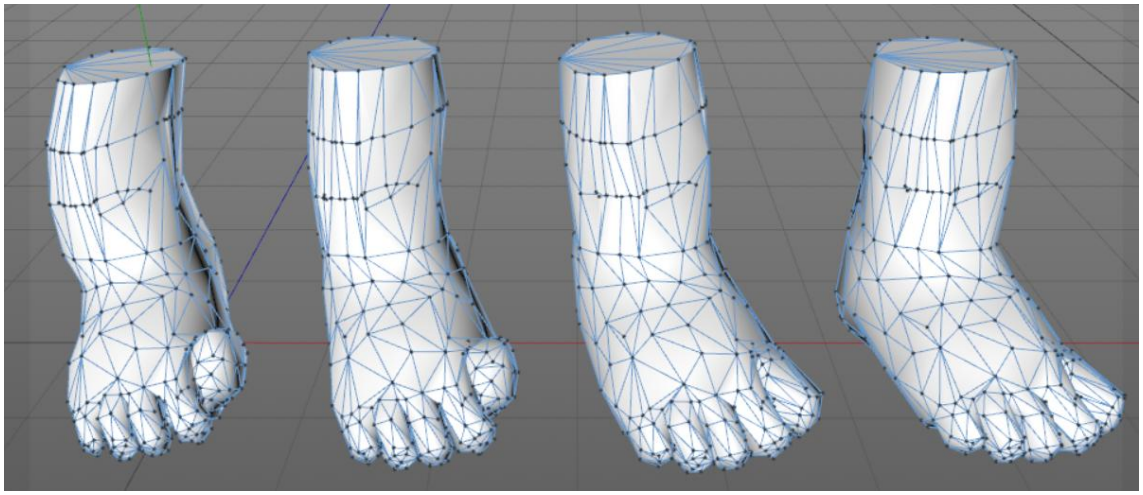

Fig-3: Simulation of gradual correction of CTEV is generated using computer model.

Fig-4: Model of orthosis is generated based on the computer model of the leg

III. Result / Discussion

A 3D printed orthosis is produced based on patient's leg. It comes with a small form factor, covering below knee area. The orthosis is lightweight, weighing at 40 grams only. It has 2 separate parts which are held together by screws, which can be detached for times such aswhen bathing the child. This method of producing patient specific CTEV foot orthosis is accurate and fast (3D printing process takes approximately 3 hours) if

compared with Plaster of Paris which takes 2 to 3 days to cure.[7,8]Polylactic acid (PLA) and its copolymers have a long history of safety in humans and an extensive range of applications. PLA is biocompatible, biodegradable by hydrolysis and enzymatic activity, has a large range of mechanical and physical properties that can be engineered appropriately to suit multiple applications, and has low immunogenicity. Formulations containing PLA have also been Food and Drug Administration (FDA)-approved for multiple applications making PLA suitable for expedited clinical translatability. These biomaterials can be fashioned into sutures, scaffolds, cell carriers, drug delivery systems, and a myriad of fabrications.[9,10]

Fig-5: The 3D printed orthosis made of PLA plastic. It consists of the anterior and posterior parts, held together with metal screws.

IV. Conclusion

The rapid prototyping technology employed for the production of this lightweight, waterproof and comfortable CTEV prosthesis, shows promising possibility of replacing the conventional Ponseti method. However this method is still in prototype stage and requires further clinical trials.

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