The Use Of 3D Printed Material For Trunk Exoskeleton System

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Abstract

Since the 60's, exoskeleton technology has fascinated scientists and engineers alike, from examples such as the early GE "Handyman" through to model XOS, a military grade heavy duty system. This technology can also be found in the clinical setting, where systems can offer patients, who may have severe spinal damage, the ability to walk again. As amazing as this technology may be, the exoskeleton is limited in accessibility as manufacturing of the devices can be quite expensive, often leading to a hefty price tag. To begin addressing this accessibility gap, this study looked at adopting the use of additive layer manufacturing (ALM), as an alternative. The work presented in this paper is part of a larger project called "Exo-Moov", where the aim is to produce a low cost, rehabilitation system.
The Exo-Moov system comprises of skeletal segment's that have been 3d printed from polylactic acid (PLA). These are linked together by a pair of central cords made from Nitrile rubber (NBR). To drive the system, two pairs of actuators have been placed at key points to aid the key muscular groups in motion. To attach the actuator to the segments, a connector system was designed, which was 3D printed in Polyethylene terephthalate with carbon (PETC). This work focuses on the drive of the human trunk while attempting to achieve a sitting state from a lying position.

When the human body begins to fire muscles, the contraction of the muscles will cause the body to begin rising. However, if these muscles have suffered damage or degradation in any way, this task cannot be achieved. Based on the calculations by Palastanga \cite{palastanga_anatomy_2011}, the force was distributed from the base of the spine and calculated for each major point of rotation. Each force was then modelled as a Boundary loading. As NBR is a hyperelastic material, the relevant module was used to create the behaviour of the cords. Within this module, the Mooney-Rivlin model was used with two parameters, each selected from work done by Kumar. To study the exoskeleton forces during the action of rising from lying to sitting, the motion was modelled as an Auxiliary Sweep.

The results of this simulation indicate that the 3d printed PLA segments are mechanically robust enough to allow our current exoskeleton design to support the human trunk under maximum regular load. Based on this, it is inferred that 3d printing components in PLA could facilitate the introduction of accessible exoskeleton technologies.

This work has been undertaken to examine the performance of PLA as a material for use in 3d printed exoskeleton structures, when subject to the load of the human trunk. The results shown in Figure indicate that under these conditions PLA is an adequate choice, providing evidence that 3d printing components out of materials of this type can serve as an alternative to the more expensive manufacturing processes and materials used in existing exoskeletons. Further simulation is however required to account for additional details, such as the infill of the 3d printed components.

Figures used in the abstract

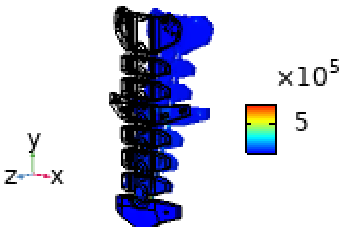


Figure 1 : "Exo Moov" trunk simulation

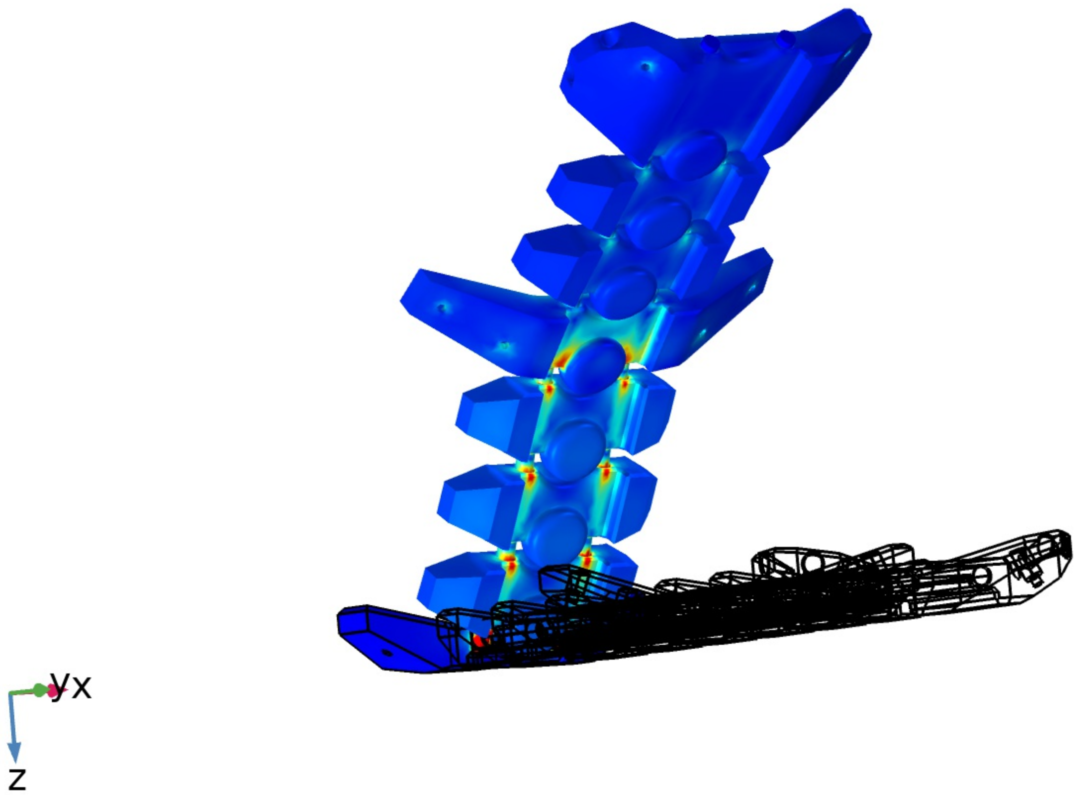


Figure 2 : "Exo Moov" Max extension

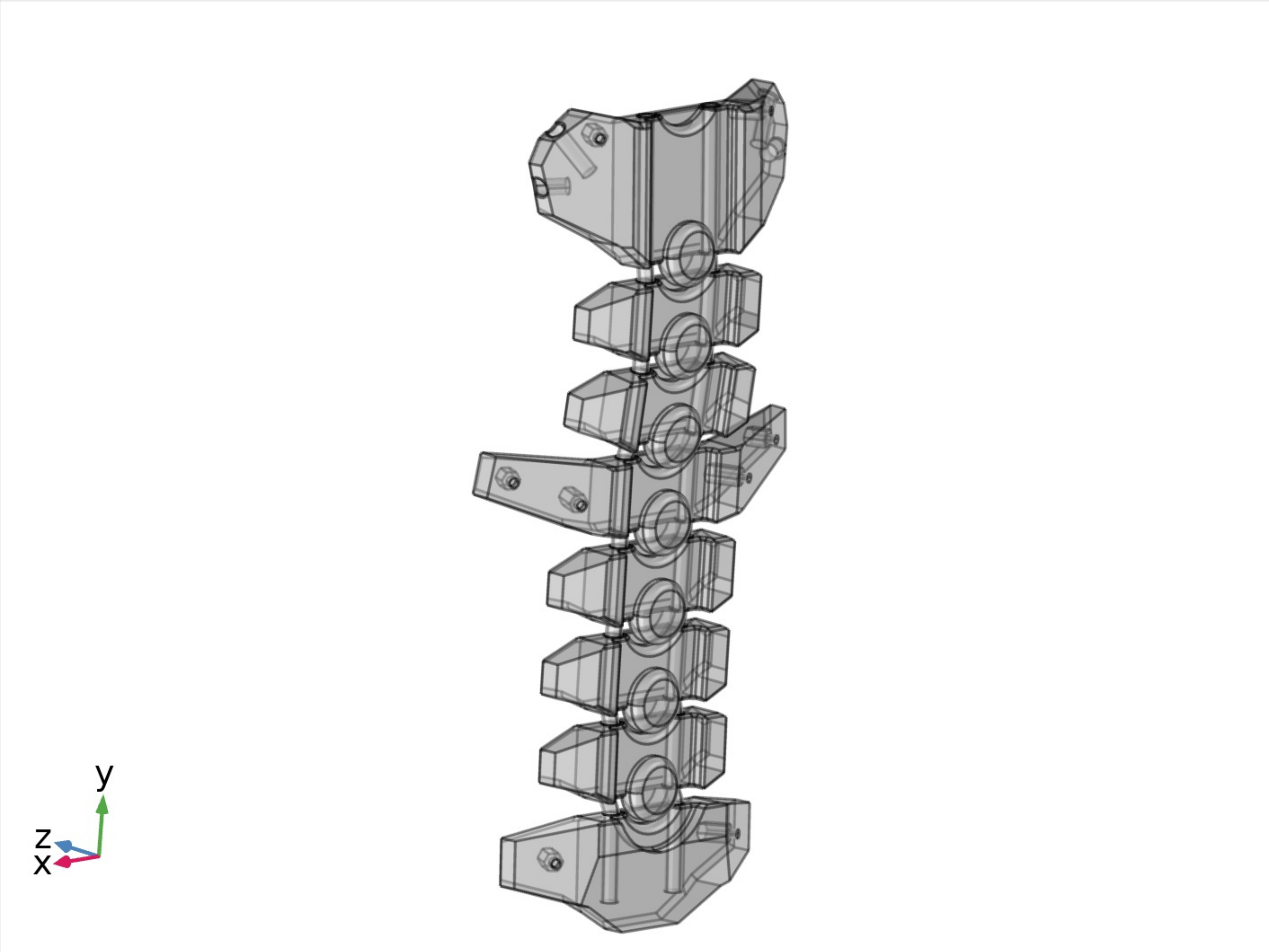
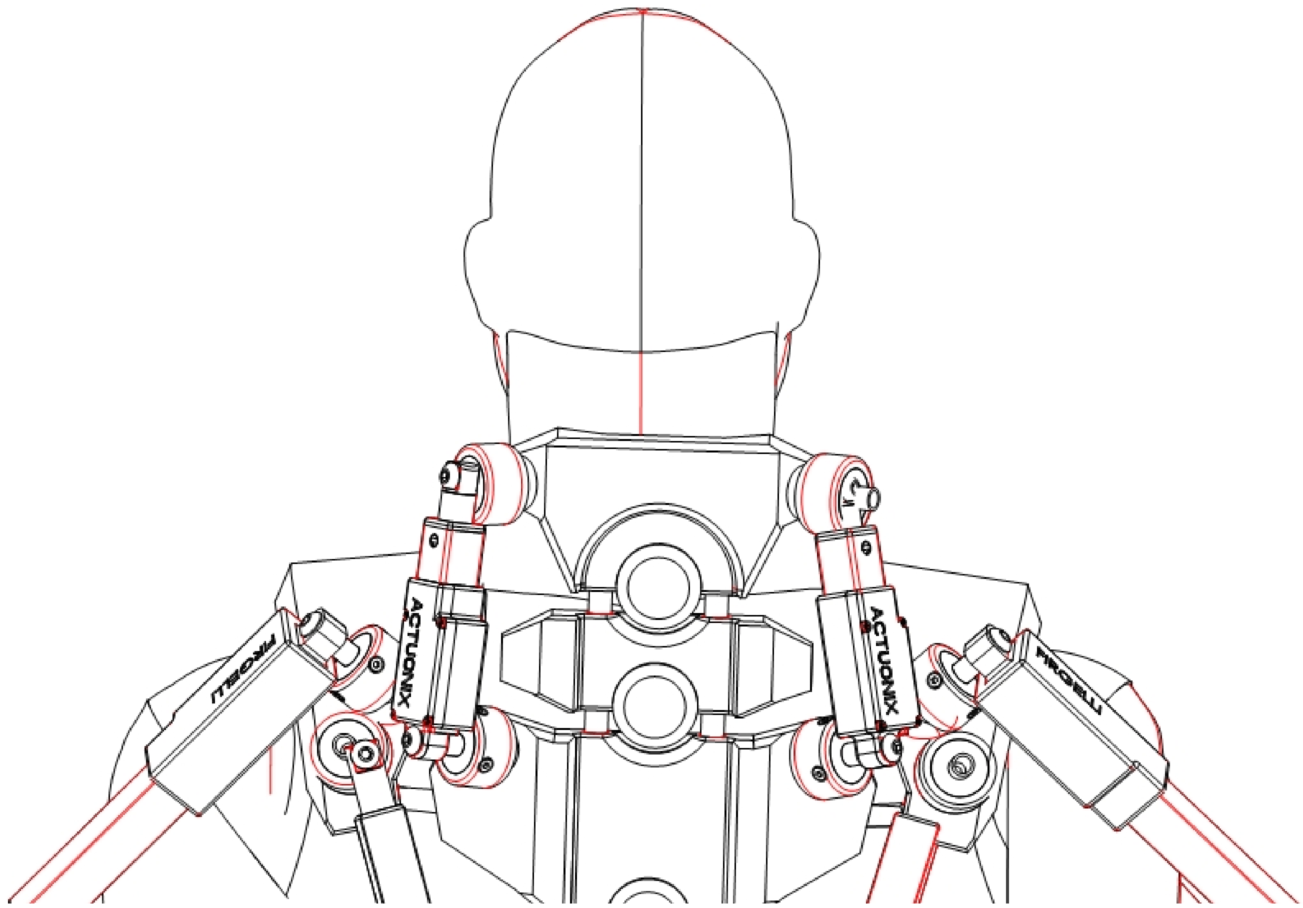
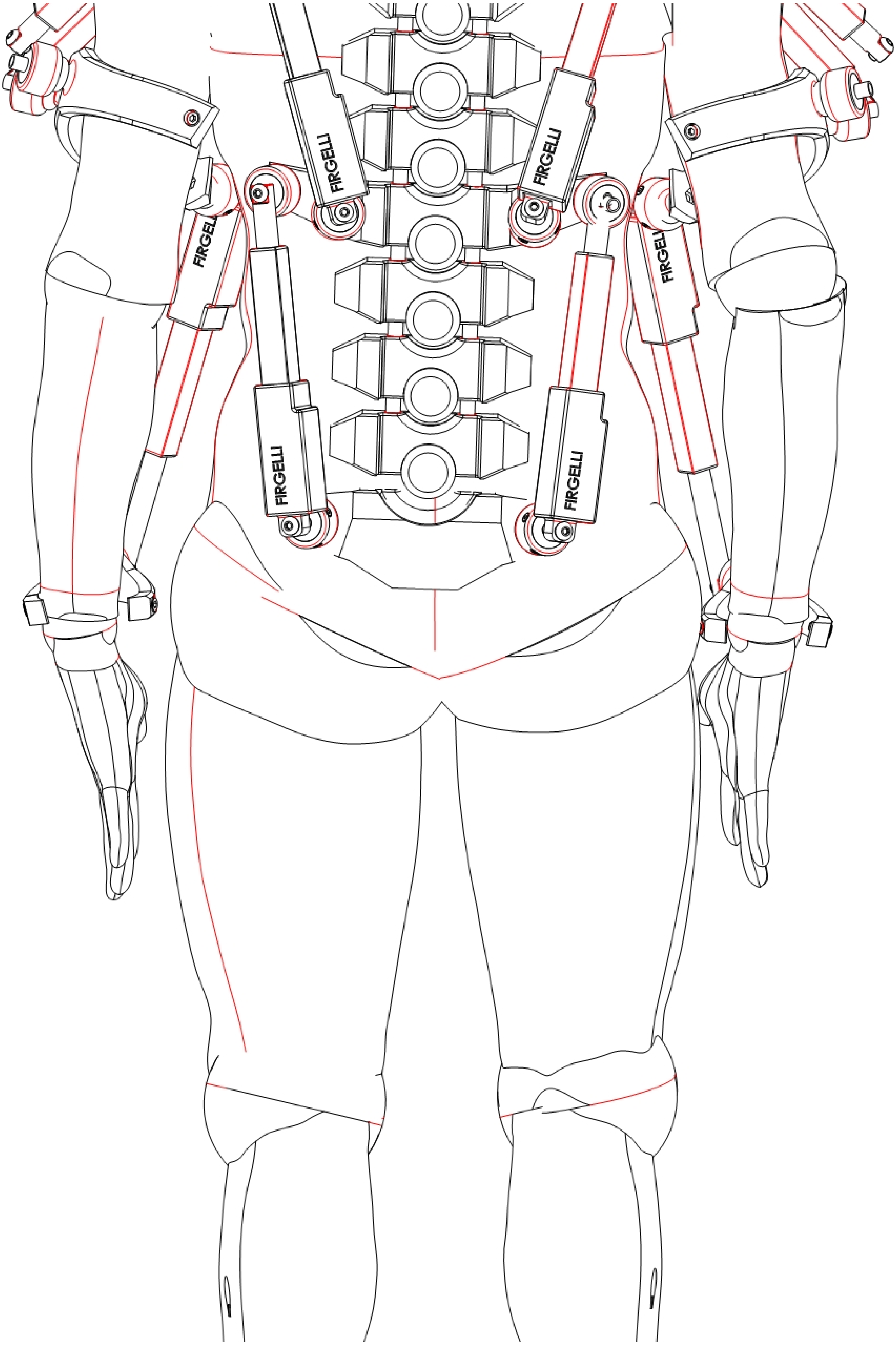


Figure 3 : "Exo Moov" trunk section un pre simulation

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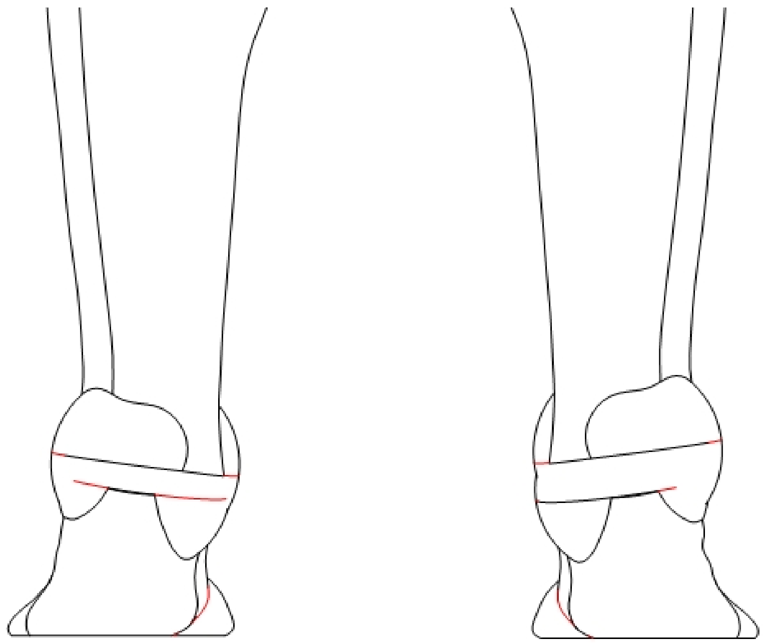

Figure 4 : "Exo Moov" fitted and a patient