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A comparison between the mechanical behaviour of steel wires and ultra high molecular weight poly ethylene cables for sternum closure

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Abstract

Sternum closure after open heart surgery is typically done with steel wires. Final approximation of sternal parts and connection is achieved by twisting the ends of the wire and bending the twisted assembly towards the sternum in order to minimize outward protrusion. Though this routine procedure is highly effective, some failures do occur, e.g. due to wire fracture. Fatigue fracture of the wires, e.g. due to coughing implies a failure risk. An alternative development is to make cables from gel spun Ultra High Molecular Weight Poly Ethylene (UHMWPE) fibres, such fibres are extremely strong, yet flexible, and if made as a very pure grade, they are highly bio compatible. The optimal connection technique will be different from that of steel. Connection will rather be with knotting than twisting. A new sternum closure and fixation technique has been developed for the sternum. Additionally, a testing technique was developed, for a connec-tion of simulated sternum parts, using different materials according to their respective optimal connection method and subsequently testing the mechanical properties of the connection. Substantial differences were observed. The mechani-cal behaviour of twisted steel wire connection showed more scatter than the knotted UHMWPE cables and some initial slack was sometimes present in the twisted cables. The maximum attainable force in the steel wires was determined by “untwisting” due to the external load. The maximum force in the UHMWPE cables was determined by the knot strength, either slipping for small knots, or breaking of the cables at the knots for slip-improved knots. The maximum force on the knotted UHMWPE cables was substantially larger than the maximum force on the twisted steel wires. Fatigue tests were performed on both the steel solution and the UHMWPE cables solution. The performance was about similar, al-though the simulated sternum opening was smaller for the UHMWPE cables at higher load levels. Summarizing, the UHMWPE cables show two advantages namely higher maximum load and more reproducible mechanical behaviour due to less scatter in the mechanical behaviour. On the other hand, the connection by knotting UHMWPE cables is somewhat more elaborate than the simple twisting connection of steel wires.

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