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Modern cast/splint for external physical injuries and rehabilitation

Physical injuries has always been a part of human life and development throughout the evolution of mankind. To accomplish certain physical tasks, there has always been some physical exertion by the human body which, over the long run, can result in internal physical injuries like muscle tears, ligament tears, hairline cracks in bones, etc. External physical injuries are a common thing of the past, present and will be for the foreseeable future. These injuries can happen to anyone at any given point of time and can leave some people in a state of inactivity for several months on end. The purpose of the multi-purpose cast is that it will be designed to minimize the work put into the recovery process while constantly providing immobilization, compression, heat treatment and airflow, simultaneously, to the injured body part from the earliest stages of injury, which can potentially reduce time taken to recover from an injury.

Keywords: cast, splint, recovery, rehabilitation

1.0 Introduction and background

The natural recovery process for an injury includes blood rushing to the injured area as the arteries and veins expand slightly (which needs to be avoided in the earlier stages of an injury to prevent swelling) as the blood then tries to clot the wound. This process is done over and over again by the circulatory system of the body until, over a period, the injury is healed. However, when there is movement (voluntary or involuntary) of the injured part or its close surrounding connective parts, there will again be some inflammation due to incomplete recovery and this can potentially slow down the recovery process considerably. The aided recovery process is how most current practices are carried out in the rehabilitation of an injury and it carried out in that systematic order – isolation, immobilization and constriction (until initial recovery is complete), followed by additional methods of rehabilitation – chiropractic, physiotherapeutic, etc.The current issues with the cast used for immobilization are: Bulky casts – plaster of paris (PoP) casts are usually bulky in order to provide the required level of immobilization. PoP casts are also not water resistant. However not very rigid. Extreme rigidity – fiberglass casts are a much better option for immobilization but are however, very rigid. They are also resistant to moisture. Maceration – the wrinkling of skin due to excessive exposure to moisture is called maceration. This can increase the likelihood of an infection if the injury. This usually happens when the cast is completely closed off and gets no exposure to atmospheric air – example – moisture accumulation under the cast after a bath or wash. It is also currently not possible to provide icing or heat treatment to an injury during the initial recovery process without compromising the immobilization or the compression which are key elements of the initial recovery period. The current available products heavily revolve around 3D scanning, 3D printing and concept designs. They are very thin, structurally stable, waterproof, easily removable, prevent infection, customizable, very comfortable and prevent muscle atrophy shown in Figs.1 and 2. However, they are extremely expensive and most orthopedics and traumatologists prefer the simplicity and availability of the traditional casts or splints over these alternatives.

2.0 Material selection process

The pro-con method of selection is employed to selecting the appropriate material with respect to the primary requirements and a few other criteria. The materials considered were orfit, fiberglass-PoP hybrid, PVC and polypropylene, materials that would provide a variety of functionality while also providing the base function of immobilization and restriction of movement to the affected region as well as its surrounding areas. We have chosen PVC for the initial prototype considering it was relatively easy to source and mold. For the main model, we have chosen to use polypropylene plastic as it does have a higher rigidity than PVC as well as greater resistance to higher temperatures.

3.0 Manufacturing process

Two PoP plaster bandages were purchased with vaseline to make the initial negative mould. The vaseline would help prevent the PoP from sticking to the skin when applies. The bandages were dipped in water and places on the arm to create an exact hollow outline of the arm, (Fig.1) to create the

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Fig.1

Fig.2

Fig.3

Fig.4

negative mould. Into the negative mould was poured a PoP emulsion with water which was dried to then form the positive mould later.

To make the final model, we decided to use polypropylene (PP) which is a flexible plastic that would provide the flexibility required after thermosetting without offering the potential breakability of PVC if too much tensile stress is applied. To fabricate the final model, a sheet of 5mm thick PP sheet was roughly cut into the shape of mould and again heated in an oven till it turned translucent and like a sheet of cloth. It was then immediately placed over the mold to take its shape and held down using an elastic strip and a pair of gloves. As it cooled, it took the required shape of the mold. Upon cooling, we outlined the precise shape that was required and then cut out the unnecessary plastic. The unfinished PP looked very similar to the PVC one (Fig.3).

To incorporate a universal fit design, we added two V-slits along the longitude of either end of the model that would allow smaller sized hands and arms to fit into the splint we intended to fabricate. We also split the model into a hand-part as well as the arm-part to adjust the height/length of hand-wrist-arm according to any person. A slotting

Fig.4

mechanism was used to pair the hand-part as well as the arm-part with a slot-housing using unit built into the arm-part of the model and was pinned down using flat-top rivets. The male part of the slot was a small piece of 5mm thick PP sheet cut into required dimensions and the housing unit was allowed a clearance if 5-6mm to allow the male-part to slide into and fit in the slot.To make the top-part of the model, again a 5mm sheet of PP of required size was heated till translucent and placed onto the PoP mould and the unnecessary plastic was cut out. The edges were grinded till smooth and a hinge was added to connect the top part to the bottom part (Figs.4 and 5). Straps were also added to allow for comfortable fastening of the injured arm into the model.

4.0 Result and discussions

- The polypropylene model allows for comfortable immobilization of the right arm of an adult of varying arm sizes, while providing sufficient exposure to atmospheric air to prevent macerations and infections of the skin.
- The model can accommodate for icing and use of hot packs when immobilized which can thereby allow for additional treatment of an injury during the initial stages of an injury.
- Raw materials used are readily available and cost of fabrication is greatly lesser than manufacturing of other types of immobilizations with the exception of a plaster of paris cast.
- Usage of polypropylene for majority of the fabrication of the final model allows for any additional diagnosis such as X-raying with the cast still applied with no interference (steel rivets can interfere, but that is something that is addressed in the next section of potential improvements).
- Manufacturing of the polypropylene cast/splint is much easier than creating expensive 3D scanning/printing models.

5.0 Conclusions

- The polypropylene model fabricated achieved all its objectives we set out to accomplish and works as intended and manufacturing of the polypropylene cast/splint is much easier than creating expensive 3D scanning/printing models.
- The fabricated cast allows for easy immobilization while maintaining rigidity required for recovery and is a considerable alternative to plaster of paris or fiberglass casts, and other methods of immobilization.
- The cast allows for icing or use of hot packs without deformation when used and is significantly less expensive tomanufacture compared to other alternatives.
- The use of plastic allows for further improvements that can be done, such as replacement of metallic rivets with plastic ones to allow for complete X-ray penetration, multiple manufacturing sizes and incorporating a sodium polyacrylate inner lining to absorb sweat, water or any fluids that come into contact with the cast/splint. (Context - This is a chemical used indiapers to absorb fluids).

6.0 References

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