Fabrication of Multi-Purpose Cast/Splint for Injury Recovery & Rehabilitation

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Abstract: 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 current trend of recovery is to isolate and immobilize the injured body part while recovery takes place, followed by external treatment via physiotherapeutic methods after an initial recovery. However, at a point in the recovery process, there will come a time when there must be heat treatment (both hot and cold) is used to aid in recovery of the wound as it improves the blood flow to the injured body part – this is where the multi-purpose cast (or splint) would come into the picture. 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.

Index Terms: Casts, Splints, Braces, Injury Recovery, Rehabilitation, Conventional Casts, Concept Cast, Cast Testing.

I. INTRODUCTION

Physical injuries have always been a part of human life and development thought 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. Now, these injuries are more common for people who physically exert themselves daily like athletes,manual labor workers, etc. and it does take them at least a week, to recover from minor physical injuries, up to several months, for much more severe ones. 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 repeatedly 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. As explained above, the use of casts, splints, braces, etc. can aid in immobilizing the body part until a certain level of recovery is attained, after which the cast or splint or brace is removed. From here on, the immobilization required is optional, although would be recommended to improve rate of recovery. There is also a certain level of compression required to maintain immobilization of the injured body part so that it does not move considerably within the cast constraints – this is again to ensure immobilization of the body part. After the time of initial recovery, when the immobilization of the injured part becomes more optional, other forms of treatment, such as, physiotherapeutic, icing, heat treatment, chiropract ctic, etc. are done to further improve the rehabilitation of the body part back to, at least, its initial state prior to the injury. The process of icing an injury is crucial right from the initial stages of an injury to its final stages as it does not allow for the expansion of arteries and veins in the affected area, therefore reduces swelling, fluid build-up, excessive inflammation, etc. It also prevents blood vessels from carrying harmful chemicals (cytokines) to the injury by constricting them. However, in the case that swelling has alreadyy occurred, this is where heat treatment would come into play. Heat helps muscles regain their flexibility even if they are swollen. 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.

II. LITERATURE REVIEW

The medical industry is massive in its innovations and some of them have been beneficial to improve the recovery of all kinds of life forms, but that especially of humans. A study was conducted to look for similar innovations as we are attempting to achieve and use ideas and knowledge from those innovations and scientific finding to better help us understand how to achieve our objectives.

[1] Mark N. Charles, MD, et al. Plaster-fiberglass hybrid casts should be considered for orthopaedic use based on their strength, stiffness, weight and cost, combined with their acknowledged advantages of good moulding ability and water resistance. The mechanical properties of Plaster of Paris and Fiberglass hybrid as well as the individual materials are also mentioned. Comparison between various mechanical properties of fiberglass, plain PoP and the hybrid of fiberglass and POP. It shows the practicality of the hybrid cast being favoured by cost and weight factors: and clearly shows that the hybrid is superior to fiberglass in terms of cost and to plain PoP.

[2] S.S. Jikan, et al. This study was to perform mechanical tests on PoP and PP to determine it's shortcomings and advantages against other cast materials. The fabrication and characterisation of polypropylene filled with recycled plaster of paris as filler was carried out.

[3] A. J. Parmar, et al. This was a study on the physical & mechanical properties of Plaster of Paris used for splinting and casting materials. POP casts were divided into three Groups of 3 different layers (2, 3 and 8 layers). Handling characters, technical easiness, or difficulties, setting time, weight, diameter, and thickness of the casts were recorded. The casts were mounted on universal testing machine and several mechanical tests were performed to plot load deflection graphs and Stress, strain, modulus of elasticity and stiffness of casts were calculated.

III. PROBLEM STATEMENT

After extensive consultation with Orthopedics and literature review, it can be established that the current issues with the cast used for immobilization are: Bulky casts – Plaster of Paris (PoP) casts are usually bulky to provide the required level of immobilization. PoP casts are also not water resistant. However, become very rigid on setting. 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

IV. OBJECTIVES

[1] To provide the injured area with comfortable compression, immobilization, and sufficient exposure to the atmospheric air to prevent maceration and infections.

[2] To provide a means of additional treatment during earlier stages of injury.

[3] To minimize or reduce manufacturing costs using readily available materials and allow for ease of application and removal.

V. METHODOLOGY

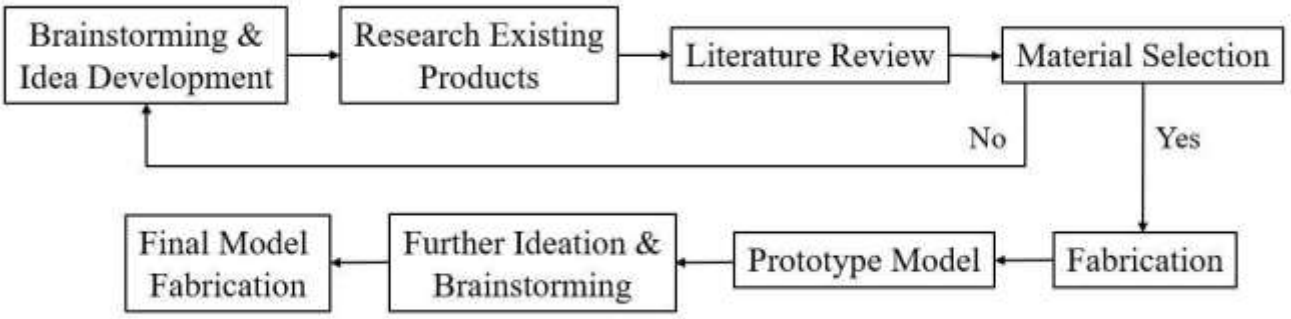

Fig.1. – Methodology Flow Chart

VI. FABRICATION

The fabrication process of the cast/splint would be done in 2 stages followed by finishing and testing:
[1] Fabrication of prototype and assessment of modifications.
[2] Fabrication of final product.

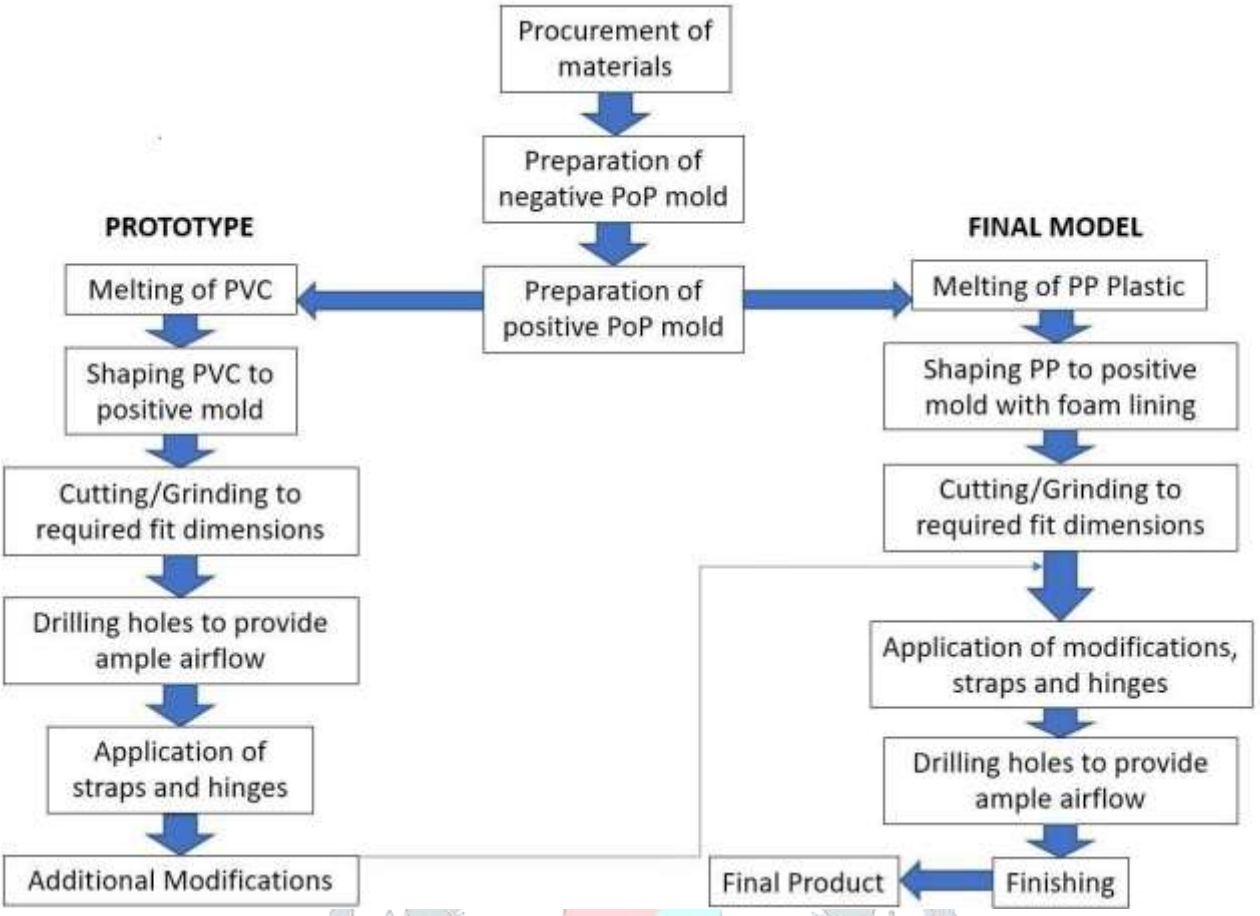

Fig.2. – Fabrication Process Flow Chart

Fig. 3. – Prototype Model without additional straps

Fig. 4.– Preliminary Final Model

Fig. 5. – Final Model

Fig. 6. – Final Model When Used

VII. RESULTS & DISCUSSION

The fabricated polypropylene model allows for comfortable immobilization of the left arm of an adult male of varying arm sizes, while providing sufficient exposure to atmospheric air to prevent macerations and infections of the skin. The model allows for icing and use of hot packs when immobilized which can thereby allow for additional treatment of an injury during the early stages of an injury. Materials used are readily available and cost of manufacturing 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 can be replaced by plastic rivets to allow for full X-Ray penetration).

VIII. CONCLUSION

- The polypropylene model fabricated achieved all the 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 comfortable immobilization whist 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 to manufacture 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 & 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 in diapers to absorb fluids.)

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