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OUTLAST TECHNOLOGY: A NOVEL PADDING MATERIAL FOR PLASTER CAST APPLICATION

Orthopedics

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ABSTRACT

Background: Plain cotton compressed into sheets is the most commonly used padding material.
Utility of a novel padding material using outlast technology was evaluated in this study.
Methods: 100 patients were divided into 2 groups. Routine padding material was used in 50 patients and outlast phase change material was used in the other 50. The two groups were then evaluated on various parameters related to patient comfort.
Results: The outlast padding material performed significantly better than the routine padding material in all the measured parameters.
Conclusion: A larger sample size, objective parameters and using patient as his own control (bilateral fractures) are needed to improve the quality of the study.

KEYWORDS

Padding material, plaster of Paris, Phase change technology

INTRODUCTION:

The name Plaster of Paris (POP) had its origins from the fact that it was extensively mined from Montmartre in Paris district (1). But its use predates the industrial revolution. Plaster of Paris has been found on the insides of pyramids too. The need to immobilize the fracture to prevent pain and deformity and all the while allowing mobilization has been the perennial problem in orthopedics. Splints made of bamboo and wooden sticks were used in the ancient times. However, these materials were flimsy and reduction was lost in most of the cases. Wax, starch, cardboard were all tried as a means for immobilization but it ended in failure. This was the time POP was beginning to be used in construction and by sculptors, surgeons observing its properties hit upon the idea of using it in orthopedics. Patients with fractures in the long bones of leg were placed in long narrow wooden boxes and the gaps filled with POP. This method was too bulky and patient moblilzation was hampered. The idea of incorporating POP in bandages was hit upon by two surgeons, Antonius Mathijsen and Nikolai Ivanovich Pirogov in the 1850's. (5)

Plaster of Paris ($2CaSO_4.H_2O$) is calcium sulphate with water. It is prepared by heating gypsum ($CaSO_4.2H_2O$) at 120°C to allow partial dehydration. When mixed with water, it gives out heat (6) and quickly sets to a hard porous mass within 5 to 15 minutes. The first step is called the setting stage with a slight expansion in volume. The second stage is the hardening stage. (2) Routine plaster of Paris hardens fully in 24 to 48 hours. Temperature of the water, impurities in the PoP, manufacturers setting time, humidity and the room temperature are the various factors which affect the setting time.

Fiber glass plaster consists of fiberglass impregnated with polyurethane polymer. It has a setting time of 1-2 minutes and full strength is achieved in 2-4 hrs. It is lightweight, water proof and has a lesser setting time than the conventional PoP. However, PoP has advantages over resin impregnated fiberglass (3) in terms of malleability, conformability and cost Commonly, PoP is used in the form of a back-slab as it can be moulded easily to produce a comfortable fit. Classically, a cotton dressing is applied around the skin. PoP bandages are dipped in water, squeezed to remove the excess water, then applied in layers around the wool dressing. This can then be moulded to the appropriate position, forming a cast. A bandage is applied to complete the back-slab, which can be done before or after moulding (4). PoP is also used in form of a Spica where a part of the trunk is incorporated in the cast.

The plaster cast application is a very common procedure done on outpatient basis in orthopedics. The most commonly used padding material used in our institute is plain cotton compressed into the sheets. This padding material is an absolute must to protect the skin from burns from the exothermic reaction which occurs as the plaster sets as well as protect the skin against the development of sores especially at the bony prominences. The main problems that the patients on a plaster cast for a long duration faced were irritation, itching and cast loosening. To tackle these problems a new technology was introduced - Outlast technology.

Outlast technology, originally developed for NASA, utilizes phase change materials (PCM) that absorb, store and release heat for optimal thermal comfort. Outlast technology is comparable to ice in a drink; as it changes from solid to liquid, it absorbs heat and cools the drink, keeping that drink at the desired temperature for longer. Outlast phase change materials work in the same way, but are microencapsulated to be permanently enclosed and protected in a polymer shell. These microencapsulated phase change materials are known as Thermocules. This encapsulation process makes the Thermocules exceptionally durable for many applications. These Thermocules can be incorporated into fabrics and fibers and have the capacity to absorb, store and release excess heat. This gives any product containing Outlast technology the ability to continually regulate skin's microclimate. As the skin gets hot, the heat is absorbed, and as it cools, that heat is released.

The study was conducted to assess the utility of phase change materials to tackle the problems faced by patients on plaster casts for long duration.

MATERIALS AND METHODS:

The study was a comparative observational study carried out at a tertiary care centre with a study duration of 1 year. It included 100 patients who were treated conservatively with cast. Informed consent was taken from all the patients. In 50 patients routine plain cotton sheets were used for padding while in other 50 patients cotton sheets with Outlast material was used. Single level blinding was done i.e. none of the patients were informed about which material was being used. Also both the materials look identical in terms of external appearance. Only the applicant was aware regarding the material used. Code A representing plain cotton sheet use, code B representing outlast material use in the patient response form. The patients were given a response form at the time of cast removal. The form included patients' responses divided into 4 categories-

1) Comfort
2) Itching

3) Skin discoloration at the time of cast removal.
4) Feeling of warmth and sweating inside the cast

These were the most common complaints that the patients on the cast had during follow-up in the out patient department. Hence, these were included in the patient response form. After consultation with a dermatologist, each category was scored from 1 to 5 in the ascending order of satisfaction using the numerical rating scale.

Inclusion criteria:
1) Patients in the age group 18 to 70
2) Patients in whom cast was maintained for a duration of atleast 4 weeks

Exclusion criteria:
1) Patients with a preexisting skin disease
2) Patients with open fractures / Abrasions

Sample case material provided to the tertiary care centre was used; hence the study did not include any additional cost to the patient.

RESULTS:
1. Demographic Details:
A total of 100 patients were recruited in the study. These patients were divided into two groups of 50 each, one group undergoing application of outlast material while the other group receiving normal cast application.

Majority of the patients in the study were females. 32 of the 50 participants (64%) in the Outlast group were females while 36 of the 50 patients (72%) in the control normal cast group were females. The mean age data in the two groups are mentioned in table 1. The mean values of the demographic variables were comparable to each other ($p>0.05$).

The mean age in both groups were comparable to each other ($p>0.05$) using unpaired t-test

2. Comfort Scoring:
We calculated the mean comfort score for both the outlast group and the normal cast group and we found that mean scores were significantly more and better in the outlast group, based on Mann-Whitney test ($p<0.05$). The mean values are given in table 2 and figure 1.

The mean scores in both groups were comparable to each other ($p>0.05$) using Mann-Whitney test (as data is non-parametric)

3. Itching Score:
The mean itching score was also calculated for both the study groups. We found that the score was significantly greater in the outlast group, indicating better patient response with regards to itching ($p<0.05$). The mean values are given in table 2 and in figure 2.

The mean scores in both groups were comparable to each other ($p>0.05$) using Mann-Whitney test (as data is non-parametric)

4. Skin Discoloration Score:
The skin discoloration score was measured for both the study groups. It was found that the score was significantly higher in the outlast group as compared to the group which used normal cast material ($p<0.05$), indicating lesser discoloration in the outcast group. The mean values are given in table 2 and in figure 3.

The mean scores in both groups were comparable to each other ($p>0.05$) using Mann-Whitney test (as data is non-parametric)

5. Sweat & Warmth Score:
Based on the mean values of the scores to measure sweat and warmth, the mean score in the outlast group was significantly higher as compared to the normal cast group ($p<0.05$), which indicates lesser degree of sweat and warmth in the outlast group. The mean values are given in table 2 and in figure 4.

The mean scores in both groups were comparable to each other ($p>0.05$) using Mann-Whitney test (as data is non-parametric)

Discussion and conclusion:

Immobilization of injured limbs has been performed for thousands of years. Before contemporary casting materials became widely used, people used a variety of materials to form rigid casts. Over the centuries immobilization has evolved from using simple wooden splints and rags to plaster of Paris, fiber and soft casts.

The success of non-operative treatment of fractures relies on a clear understanding of fracture healing and the proper use of stabilizing techniques. Non-operative management of fractures has been declining in recent years due to significant advances in operative technology and greater patient expectations of an early return to activity. Younger surgeons are not as familiar with non-operative treatment of fractures with a plaster cast as their predecessors. This is due to a lack of experience in application of plaster casts and the subsequent management. Plaster of Paris is unique and still remains the favored casting material in many countries (2). It is cheap, non-toxic, and can easily be moulded to the desired shapes and contours of the body.

A fiberglass cast is a newer synthetic alternative to plaster of Paris. Fiberglass cast is a lightweight and extremely strong material. Fiberglass, also called glass-reinforced plastic (GRP) or glass fiber reinforced plastic (GFRP) is a fiber reinforced polymer made of a plastic matrix reinforced by fine glass. As compared to traditional plaster of Paris cast, it is light in weight and more durable. It is three times stronger and but is only one third in weight. Fiberglass cast is a lightweight and extremely strong material (7). Fiberglass cast is used for fracture management but is not applied in the acute settings because it is less accommodating to swelling and does not allow moulding.

Common complications associated with plaster of Paris application include deep vein thrombosis, compartment syndrome, allergic dermatitis, pressure sores etc. This is where padding material comes into play. Dermatological complications including pressure sores and allergic dermatitis can be minimized by using appropriate padding material. Traditionally cotton sheets have been utilized for the purpose of padding. Patients on plaster cast for a long duration complain regarding itching and a feeling of discomfort. To obviate these common symptoms, we assessed the utility of padding material using the Outlast phase change technology.

Outlast technology was originally developed for NASA to protect Astronauts in space from temperature fluctuations. Outlast technology enhances textiles by providing the benefit of proactive temperature regulation that manages heat and moisture. It absorbs, stores and releases heat for optimal thermal comfort. These temperature regulating textiles adjust to the skin's microclimate and offer more comfort through proactive heat management and active temperature regulation.

However, these advantages in textiles had never been studied in a padding material for plaster of Paris application. Hence we carried out a randomized controlled trial to assess the utility of the Phase change materials using outlast technology in plaster padding and evaluated the patient comfort.

The outlast material performed better than the routine padding material in all the parameters that were assessed. However, the fallacies of the study include:

1) Relatively small sample size
2) Measured parameters were all subjective
3) Patient did not serve as his own control

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