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Role of Low Level Laser Therapy in Management of Pediatric Thermal Burn

Jibetosh Biswas[1], Ravi Kumar Chittoria[2], Barath Kumar Singh .P[3]

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Abstract

Low level laser therapy (LLLT) has a role in wound bed preparation, wound healing process, joint stiffness, nerve regeneration, antimicrobial action and prevention of postburn scarring. Superficial burns are usually managed by healing by secondary intention. Deeper burns need early excision or debridement followed by cover by either skin graft or flap. Regenerative technology like low level laser therapy (LLLT) helps in healing of superficial burns. Further, Low Level Laser Therapy (LLLT) helps in controlling infection & promoting healthy granulation so that burn wound could be covered with skin graft or flap. After wound healing LLLT helps in prevention of hypertrophic or abnormal scarring. In this study, we studied the role of LLLT in management of pediatric thermal burns.

Keywords: Low level laser therapy; Pediatric; Thermal burns.

INTRODUCTION

Thermal burns are the most common modality seen in the pediatric group, mostly due to accidental fall of hot water (scald injury). Post thermal burn injury patient may develop a post burn scar or contracture if there is a delay in treatment. Low level laser therapy (LLLT) has a role in wound bed preparation, wound healing process, joint stiffness, nerve regeneration, antimicrobial action and prevention of postburn scarring. Superficial burns are usually managed by healing by secondary intention. Deeper burns need early excision or debridement followed by cover by either skin graft or flap. Regenerative technology like low level laser therapy (LLLT) helps in healing of superficial burns. Further, Low Level Laser Therapy (LLLT) helps in controlling infection & promoting healthy granulation so that burn wound could be covered with skin graft or flap. After wound healing LLLT helps in prevention of hypertrophic or abnormal scarring.[1] Limited clinical studies are available on role of LLLT in the management of pediatric thermal burns. In this study, we studied the role of LLLT in management of pediatric thermal burn wounds.

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METHODS AND MATERIALS

This study was conducted in the plastic surgery department in JIPMER tertiary care center. Informed written consent was taken from the patient. The study was done on a one year old boy with no known comorbidities, sustaining 20% second degree mixed burns (superficial and deep) injuries over the right upper limb, hand, trunk due to accidental fall in hot water, while playing (Fig. 1). After resuscitation and acute management, for burns wounds plan was to manage superficial burns with medical management including dressing & adjuvant LLLT (Fig. 2). For deeper burns, plan was to do early tangential excision & skin grafting (Fig. 3). We used Gallium Arsenide (Ga As) diode red laser of wave length 650 nm, frequency 10 kHz and output power 100 mW. It was a continuous beam laser with an energy density of 4 J/cm2. The machine delivers laser in scanning mode (non-contact delivery) with a 60 cm distance between the laser source and wound. Superficial burn wounds were given low level laser therapy for duration of 125 seconds every time. Two sessions were given every 3rd day. Results were evaluated by noting total time taken in healing of superficial and deeper burns.

Fig. 1: 20% mixed (superficial & deep second degree) scald thermal burns over chest, abdomen and right arm.

Fig. 2: Application of low level laser therapy forsuperficial scald burns

Fig. 3: Skin grafting done for deeper burns

Fig. 4: Status after complete wound healing

RESULTS

Superficial burns healed in 7 days. deeper burns healed in 10 days. Donor site of skin graft healed in two weeks (Fig. 4). Post-operative period was uneventful. No complications were noted related LLLT or surgery. patient was discharged after rehabilitation in 3 rd week.

DISCUSSION

The acronym LASER can be abbreviated as "*light amplificationby stimulated emission of radiation*". Low level lasers are definedby a power density at less than 500 mW/cm2. It is defined as low level laser as the energy used is much less than that is usedfor cutting, ablation therapy. Low-level laser therapy (LLLT) hasbeen used as an adjuvant to conventional therapy with promising results, especially in patients with acute and bloody ulcers.[1] LLLTis a form of phototherapy that employs electromagnetic radiation capable of generating enough energy to interact with living tissues. It produces photochemical and photophysical effects without generating heat, with the intention of re-establishing cell homeostasis. Essentially, light energy is delivered topically in a controlled, safe manner and it is absorbed by photo absorbers (chromophores) that transform it into chemical energy. Positive effects include acceleration of tissue repair, increased formation of granulation tissue, wound contraction, inflammation, modulation, and pain reduction.[2] According to the literature, low-energy photoemissionsgiven at a wavelength range of 600 nm to 900 nm accelerates cellproliferation and wound healing processes.[3,4,5]

Laser therapy is a painless, cost effective procedure which induces faster granulation, wound contraction and re-epithelialization. It thus accelerates complete wound healing, avoiding the need for secondary procedures like split skin grafting. Controlof infection is also better in patients whom low-level laser therapywas given.6In addition to reducing the lesion area and acceleratingthe healing process, laser therapy has the advantage of being easilyadministered. These benefits assist in promoting patient quality oflife and minimizing possible complications.[6]

In our study we used LLLT for healing superficial burns as an adjuvant regenerative technology & was found to be useful. Limitation of our study is that it's a single patient based study with no control done in a single Centre. large randomized controlled multicentric studies are required to substantiate result of our study.

CONCLUSION

Low Level Laser Therapy (LLLT) is an adjuvant regenerative technology helps in the healing of superficial burns.

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Role of Hybrid Reconstruction Ladder in Pediatric Scale Burn

Jacob Antony Chakiath[1], Ravi Kumar Chittoria[2]

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Abstract

Multidisciplinary team has effectively adapted advanced reconstructive techniques merged with regenerative medicine modalities to improve outcomes. These treatments combine traditional reconstruction measures with regenerative medicine applications and has been termed 'hybrid reconstructions'. The hybrid reconstruction model aids in maximizing the function while minimizing the disability and morbidity associated with traditional reconstruction.

Keywords: Hybrid reconstructive ladder; Scald burns.

INTRODUCTION

The reconstructive ladder is a concept familiar to all plastic surgeons. Although it has undergone gradual evolution over time, the basic concept of methods of reconstruction ranked by complexity has been preserved and propagated in multiple forms. Most descriptions start with closure by secondary intention, followed by direct closure, local flaps, and distant flaps. Various authors have made finer distinctions among local, regional, and free flaps, and inserting tissue expansion somewhere in the spectrum.

The complex injury pattern has initiated efforts to create new and innovative techniques in tissue regeneration. Multidisciplinary team has effectively adapted advanced reconstructive techniques merged with regenerative medicine modalities to improve outcomes. These treatments combine traditional reconstruction measures with regenerative medicine applications and has been termed hybrid reconstructions.[1]

The hybrid reconstruction model aids in maximizing the function while minimizing the disability and morbidity associated with traditional reconstruction. In aim of this study is to apply the hybrid reconstructive mole in our patient with a non-healing wound in the left knee.

MATERIALS AND METHODS

The study was carried out in a tertiary care hospital in South India after receiving approval from departmental ethical committee. Informed

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consent was obtained for examination and clinical photography. 1 year old male child presented with accidental scald burns which was second degree superficial and deep (mixed) burn over right upper limb and anterior chest and abdomen (Fig. 1). A hybrid reconstruction approach was carried out for his scald burn management. He underwent tangential excision and wound bed preparation like autologous platelet rich plasma (Fig. 2) followed by skin grafting, pixel grafting (Fig. 3) and cyclic negative pressure wound therapy (NPWT) (Fig. 4).

Fig. 1: Scald burn at the time of presentation

Fig. 2: Wound bed preparation using autologous platelet rich plasma

Fig. 3: Post tangential excision skin grafting and pixel grafting

Fig. 4: Cyclic negative pressure wound therapy

RESULTS

In this patient, Hybrid reconstruction ladder approach helped in complete healing of the second degree superficial burn and in second degree deep burn, it helped to wound bed preparation and good take of skin graft (Fig. 5).

Fig. 5: Results of hybrid reconstruction ladder approach

DISCUSSION

The reconstructive ladder is an improper extension of a well-known and appropriate concept of a wound closure ladder. It has its own limitations. Although there is virtue in using the simplest solution to a given problem, at times more complex methods of reconstruction may be preferred, even when simpler methods can achieve wound closure. To address these concerns, several modifications to the reconstructive ladder have been proposed. Mathes and Nahai[2] suggested the "reconstructive triangle," which consisted of tissue expansion, local flaps, and microsurgery.

Gottlieb and Krieger[3] introduced the "reconstructive elevator" which, although still acknowledging the concept of increasing levels of complexity, suggests the freedom to ascend directly to the appropriate level if necessary.

Wong and Niranjan[4] recommended that the rungs be thought of as stages in the development of surgical skills, emphasizing that the difficulty of a reconstructive problem is related to the skill and training of the treating surgeon. Erba et al.[5] integrated the concepts of surgical risk, technological complexity, and surgical complexity into a matrix to help organize the various reconstructive methods and provide a framework for further discussion.

The reconstructive grid[6] is a dynamic construct that takes into account the multiple reconstructive options available to the plastic surgeon. It also takes into consideration factors that help the reconstructive surgeon determine the best possible option to achieve the three reconstruction goals, namely, form, function, and aesthetics. The factors that aid the judgment of a reconstruction specialist, including wound complexity, surgeon skill, resources (and technology) available, and patient requests, form the boundaries of the reconstructive grid.

Surgeons' Skills

Resources available

Bionegineered tissue					Superricrosurgery	
Oxygen therapy					Roboitic Microsurgery	
Extracellular matrix			Tissue expansion		Functional tissue transfer	
External tissues expansion			Pertorator flaps	Islanded flaps	Perforator free flaps	Abdominal wall transplant
Cell therapy & Growth Factors	Gene therapy & Tissue Engineering	Composite graft	Keystone flaps	Composite flap	Composite free flap	Face transplant
NPWT	In-utero reconstruction	Corrporent graft	Dermal flaps	Corrponent flaps	Comporent free flap	Hard transplant
Secondary healing	Primary closure	Craft	Local flap	Distant flap	Free flap	Vascular Composite Allotransplant

Patient requests

Wound complexity

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The bottom row of the reconstructive grid houses the traditional modalities of reconstruction that are available in the ladder and elevator and the newer reconstruction modality, vascular composite allotransplant which, though absent in the reconstructive ladder, is mentioned in the modified reconstructive elevator.[7] The boxes above these primary reconstruction modalities show techniques available within each modality of reconstruction. The spatial nature of the reconstructive grid permits the specialist to select multiple options for a given defect. The reconstructive grid includes newer wound healing techniques such as bioengineered skin, cell therapies (e.g., adipocyte derived stem cells), and also still developing reconstruction techniques including tissue engineering[8] and gene therapies.[9] The blank boxes represent available space to accommodate newer techniques as they arise, under each modality, thus making the grid future ready.

The standard treatments for extremity injuries with massive composite tissue loss (bone, skin, soft tissue, nerves) require a spectrum of therapies. These therapies include extremity amputation, limb shortening to assist in residual limb soft tissue coverage, free tissue transfers, pedicle flaps, local flaps, skin grafting, bone reconstruction, nerve repair or reconstruction and vascular repair. The traditional therapies may subtract from an already decreased functional capacity and may result in significant donor site morbidity. Revised amputations may have non-pliable and/or nondurable surface areas prone to erosive wear with prosthetic use. Furthermore, the multiple limb injuries and amputations seen in combat casualties typically involve expanded zones of injury that extend beyond the directly affected extremities that can complicate reconstructive efforts.[7] Furthermore, in the multiple extremity injured service member, the common accepted donor sites for autologous tissues become increasingly limited.

Consequently, this has led to increased use of regenerative medicine modalities to enhance tissue regeneration and improve reconstructive outcomes. Hence the term "Hybrid Reconstruction Ladder". (Fig. 5)

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The reconstructive ladder was a term coined by plastic and reconstructive surgeons to describe levels of increasingly complex management of soft tissue wounds.[10] Theoretically, the surgeon would utilize the lowest rung of the ladder – that is, the simplest reconstruction technique – to address a clinical reconstructive problem.[11] The reconstructive surgeon would move up the ladder as a more complex or suitable method was required for a given reconstruction problem. A hybrid reconstructive ladder that augments the traditional reconstructive ladder with regenerative medicine modalities.[12] There were improved outcomes at each rung on the reconstruction ladder and these modalities may allow for the expansion of indications for each rung on the reconstruction ladder.

The study effectively employed dermal regenerates, soft tissue regeneration techniques, biologic scaffolds, fat grafting techniques and adipose-derived stem cells in a number of reconstructions.[13]

INDICATIONS

The utilization of high-concentration allogeneic mesenchymal stem cell (MSCs) for segmental and severely comminuted osseous deficits.[14]

The dermal regeneration templates for preparation and to improve the durability of wound beds for skin grafting.

The biologic scaffolds such as urinary bladder matrix to provide for soft tissue regeneration, surgical wound bed preparation and muscle regeneration.[15]

The decelluarized allograft nerves to serve as nerve regeneration templates or conduits for segmental nerve defects in patients lacking adequate auto-graft nerve sources.

ADVANTAGES

The dermal regenerates have reduced skin erosion rates compared with those patients with skin grafting alone.

It has reduced wound healing issues surrounding the prosthetic wear sites by increasing durability.

Orthopedic union rates and nonunion rates have been reduced by adjunctive use of these measures when compared with traditional reconstructions without bony regenerates.[16]

These regenerative techniques have addressed bony healing and wound healing as well as salvage failed cases, which includes improving limb salvage rates, amputation preservation of length, and carefully selected cases,[17,18]

Even in patients with limb loss and multiple extremity amputations, using these modalities has allowed residual limbs to be preserved at a length suitable for prosthetic fitting.[19]

It may be extracted to treat lesser severe injuries from trauma, burn or oncologic cases using hybrid reconstructions.[20,21]

Disadvantages: High cost

Requirement of high infrastructure

Training to learn the skill.

CONCLUSION

The Hybrid Reconstruction Ladder approach shown to an effective approach for the rapid improvement and healing in a paediatric scald burn.

Conflicts of interest: None

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A Management of Scald Burns in Pediatric Population: Our Experience

Sowmya[1], Neljo[2], Ravi Kumar Chittoria[3]

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Abstract

Injuries remain the leading cause of pediatric mortality, and burns are the fourth most common mechanism of injury, Younger children more commonly present with scald burns; whereas, flame burns are seen more often in adolescents.[1] We had a case of 25 percent pediatric scald injury for whom we had used various novel regenerative methods and we would like to share our experience of the same.

Keywords: Scald Burns; Pediatric Burns; Regenerative Methods.

INTRODUCTION

Treatment of burn wounds has always proved challenging in the pediatric population. When treating large surface area or complex burn wounds, pediatric patients frequently have limited area of graft donor sites. Infants often have skin too thin to be harvested for skin grafting and to provide adequate coverage for reconstruction. Burn scars repeatedly become hypertrophic and are hard to treat. This poses a unique challenge for the paediatric population which calls for unique and novel methods of burn management.

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MATERIALS AND METHODS

This novel method was studied on our patient– Miss Nivetha who had sustained 25 percent accidental scald burns to the chest abdomen and both upper limbs and left knee. On presentation she was managed with iv fluids, iv analgesics and iv antibiotics and regular dressing. Patient's wound bed preparation was done with 3 blood transfusion and also low level laser therapy (LLLT), autologous platelet rich plasma (APRP), Hydrojet debridement, wound debridement and split thickness skin grafting on 29.4.21. Wound was opened on post operative day 7 – which showed good take.

RESULTS

Through our experience we have observed that these novel eregenerative measures were very instrumental in reducing hypertrophic scars and subsequent contracture. They helped in reducing the duration of hospital stay by allowing easier uptake of the skin graft. However, it needs large scaled multicentric randomised trial before it can be used in clinical practice.

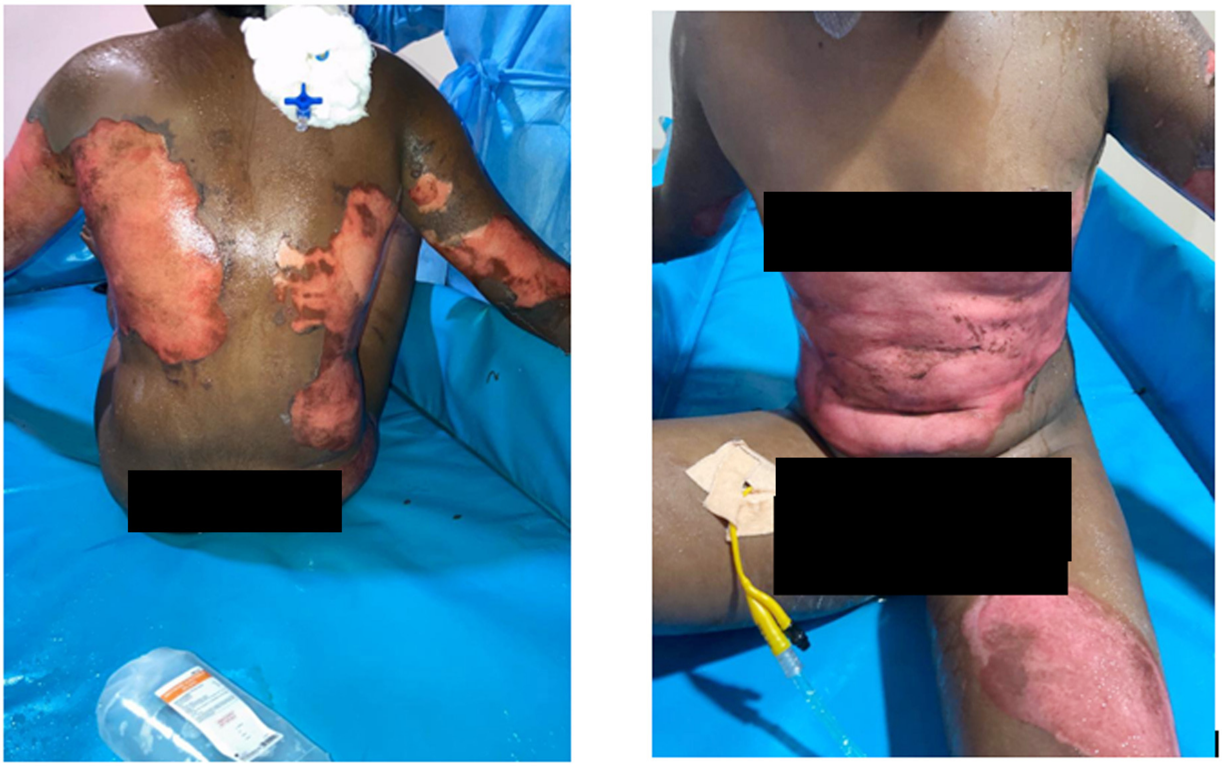

Fig. 1: Presentation of Patient

Fig. 2: Aprp therapy being given

Fig. 3: Lllt Therapy for Better Graft Uptake

Fig. 4: Healed Burn Injury

DISCUSSION

Low level laser therapy applications include: acceleration of wound healing, enhanced remodeling and repair of bone, restoration of normal neural function. following injury, pain attenuation, and modulation of the immune system.[2] Laser therapy increases both the rate and the quality of healing, and studies show that as the healing rate increases, bacterial cultures decrease, suggesting a bioinhibitory effect upon wound infection.[3] Nussbaum et al.[4] analyzed the interactions between wavelength and bacterial growth of Pseudomonas aeruginosa, Escherichia coli, and Staphylococcus aureus and reported that irradiation with 1–20 J/cm2 at a wavelength of 630 nm appeared to be commonly associated with bacterial growth inhibition, which is of considerable importance for wound healing. LLLT heps in preventing hypertrophic scar management and keloid by reducing IL-13 , IL -15, MMP's, IL-6 mRNA levels which are involved in abnormal wound healing.

Some added benefits of LLLT over other conventional methods of burn healing include:

- LLLT can be used in those patients for wound bed preparation to allow better graft take
- LLLT can be used as a prophylactic measure to alter the abnormal wound healing process by attenuating the tendency to form hypertrophic scars and keloid.

Hydrojet Debridement

Hydrotherapy is the use of water or saline under pressure to mechanically remove microscopic debris and bacteria. There are two types of hydrotherapy commonly practiced, whirlpool and pulsed lavage therapy. Whirlpool therapy supports wound healing by debriding the wound, warming the injured extremity and providing buoyancy and gentle limb resistance for physical therapy.[10] However, whirlpool treatments have fallen out of favour secondary to the risk of nosocomial contamination and transmission of virulent infections.[5,6]

Aprp Therapy in Burns

APRP gel has been used extensively to treat acute and chronic wounds, and is considered to be advanced therapy for healing. Studies have found decreased levels of growth factors in chronic wounds when compared to acute injuries.[7-9] It is thought that the application of aPRP gel directly to the wound site would increase the level of key growth factors, and thus speed the healing process.

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Reactive Arthritis in Chidren

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Abstract

The term reactive arthritis was first introduced in 1969 as to describe a sequel to an old infection, usually being genitourinary or GI infection. This condition has a diverse clinical manifestations. Initially it was know as Reiter's disease or Fiessinger Leroy disease. It is a member of spondyloarthritis family. HLA-B27 is a known predisposing genetic factor and is triggered by systemic infection. CREG-B7 group of antigens are found in B27 negative patients and these antigens are cross reactive to B27. Long term follow up is needed in children to determine if more number of children develop recurrent arthritis or any other disease like psoriatic arthritis, ankylosing spondylitis etc. cytokines like TNF alpha and interferon secrete T helper cells which help in eliminating the bacteria. NSAIDs, corticosteroids and antibiotics play a role in mainstay treatment. Reactive arthritis is characterized by both articular and extra-articular symptoms. Extra-articular manifestations include genitourinary symptoms, ocular symptoms, skin manifestations and cardiac manifestations. The diagnosis of this conditions is mostly clinical. Eliminating the infectious agent is the mainstay of the treatment followed by NSAIDs, corticosteroids and DMARDs in severe cases not responding to primary treatment is important.

Keywords: Reactive arthritis; Spondyloarthritis; NSAID; Children.

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INTRODUCTION

Reactive arthritis and post-infectious arthritis are defined as swelling of joints caused by a sterile inflammatory reaction following a recent or remote infection.[1-5] This condition usually occurs after an enteric infection with Salmonella species, Shigellaflexneri, Yersinia enterocolitica, Campylobacter jejuni, or GU tract infection with Chlamydia trachomatis. Majority of the patients with reactive arthritis are positive for HLA-B27 antigen. The cause of reactive arthritis is found to be due to Incomplete elimination of bacteria and its products, such as DNA. Ramesh BN et al[6] stated that rheumatoid arthritis (RA) is an autoimmune disease and a symmetrical polyarticular disease of unknown cause that affects mainly the diarthrodial joints, which is characterized by chronic swelling of the synovial joints. Colmegna I et al[5] stated that In 4th century B.C. Hippocrates was probably the first person who mentioned the term re active arthritis (ReA) when he noted that "Young men do not suffer from gout until they initiated sexual activity". Reactive arthritis is a joint inflammation developing after or during an infection elsewhere in the body, but the organism cannot be isolated from the joint. Reactive arthritis was observed to be inlink with gastrointestinal infections with bacteria such as Shigella, Salmonella, and Campylobacter species as well aswith genitourinary infections especially with Chlamydia trachomatis. Ajene AN et al[7] did systematic review in 2013 in which it was found that the mean incidence of reactive arthritis was 12, 12 and 9 cases per 1,000 of Salmonella, Shigella and Campylobacter infections respectively. This condition usually develops 14-28 days after a GI or genitourinary infection. Inman R. D et al[8] said that ReA is a pathological process in which there is an interaction between environmental and genetic factors. Inflammation occurs in joints, axial skeleton, skin, mucous membranes, gastrointestinal tract, and eyes. There is 50 times increased chance of developing reactive arthritis in patients with HLA-B27 positive. Sieper J et al[12] said that The arthritogenic peptide hypothesis states that there are microbial antigens which mimic certain self-antigens in the host, causing HLA-B27-specific CD8 T lymphocytes to react and leading to swelling of the joints. This would be due to molecular mimicry, a conditionin which there is a structural similarity between foreign and self-antigens that cause foreign peptides to give rise to a B or T-cell auto reaction.[13] Bas et al.[14] suggested that the cytokine reaction in HLA-B27 positive patients may have a part in improper elimination of the pathogen, which may lead to more severe or chronic arthritis.

CLINICAL FEATURE

The onset of this condition is usually sudden and characterized by lethargy, malaise and fever. The major presenting symptom of reactive arthritis is oligoarthritis mainly involving the lower extremities and is assymetrical. The inflammation causes pain, swelling, stiffness and redness of the joints that are involved. Non-joint areas involved in reactive arthritis are eyes, genitals, urinary tract, skin, large bowel, and the aorta. Conjunctivits and uveitis presents with redness of the eyes, pain, irritation and blurred vision. Urinary tract inflammation commonly involves the urethra. Minority of patients with reactive arthritis, especially those with chronic arthritis, will eventually develop cardiac manifestations including pericarditis and aortic regurgitation. Reiter triad includes urethritis, conjunctivitis, and arthritis may occur. Leirisalo-Repo M et al[9] described that Sacroiliitis occurs in approximately one third of the patients with urogenital reactive arthritis and in one tenth of patients with enteric reactive arthritis. Mucocutaneous lesions are observed in more than 50% of patients. Kim PS et al[10] described that Keratodermablennorhagica is highly specific of reactive arthritis. These are thepustular lesions, which are classically found on plantar regions, which may turn scaly and hyperkeratotic and coalesce to form psoriatic plaques. Circinatebalanitis is distinguished by painless, shallow psoriasiform lesions over the glans or shaft of the penis.

INVESTIGATIONS

Reactive arthritis cannot be diagnosed by a single lab test. ESR and CRP are elevated at the onset of the disease and later may become normal in the chronic stage of thedisease. There may be mild leukocytosis and anaemia in the early phase. The rheumatoid factor is usually negative. Gram staining and bacterial culture of the synovial fluid should be performed to differentiate from septic arthritis.[11-14]

TREATMENT

Identifying and eliminating the underlying infectious agent using appropriate antibiotics should be the main goal of the treatment. NSAIDs, Corticosteroids and immunosuppressants are needed for patients with severe reactive symptoms who do not respond to initial treatment. Sulfasalazine is beneficial in some patients. Methotrexate can be given in patients who present with rheumatoid likearthritis. Meyer et al.[15] has done a study in 10 patients with refractory Re A who did not respond to traditional drug therapy. All 10 patients were treated with anti-TNF antibodies, including five with infliximab, four with etanercept and one with adalimumab. In nine cases, treatment was effective, with significantly decreasing CRPand reduced joint symptoms. One patient did not respond to infliximab. Sieper J et al[16] stated that in case of ReA patients with tendinitis or finger or toe inflammation, with no improvement in condition with NSAIDs and anti-rheumatic drugs, then the anti-TNF antibody should be taken into consideration.

CONCLUSION

Reactive arthritis is characterized by both articular and extra-articular symptoms. Extra-articular manifestations include genitourinary symptoms, ocular symptoms, skin manifestations and cardiac manifestations. The diagnosis of this conditions is mostly clinical. Eliminating the infectious agent is the mainstay of the treatment followed by NSAIDs, corticosteroids and DMARDs in severe cases not responding to primary treatment is important.

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Application of Plaster of Paris, Splints and Casts in Plastic Surgery

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Abstract

Plaster of Paris has traditionally been the preferred material for splints and Casts. The ability to properly apply casts and splints is a technical skill easily mastered with practice and an understanding of basic principles. Once the need for immobilization has been determined, the physician must decide whether to apply a splint or a cast. Splinting involves subsequent application of a non-circumferential support held in place by an elastic bandage. Casting involves circumferential application of plaster or fiberglass. This review article gives an overview of application of Plaster of Paris, Splints, Casts in Plastic Surgery.

Keywords: Plaster of Paris; Splints; Casts.

INTRODUCTION

The ability to properly apply casts and splints is a technical skill easily mastered with practice and an understanding of basic principles. The initial approach to casting and splinting requires a thorough assessment of the skin, neurovascular status, soft tissues, and bony structures to accurately assess and diagnose the injury. Once the need for immobilization has been determined, the physician must decide whether to apply a splint or a cast.[1]

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Plaster has traditionally been the preferred material for splints. Plaster is more pliable and has a slower setting time than fiberglass, allowing more time to apply and mould the material before it sets. Materials with slower setting times also produce less heat, thus reducing patient discomfort and the risk of burns. Fiberglass is a reasonable alternative because the cost has declined since it was first introduced. It produces less mess, and it is lighter than plaster. Fiberglass is commonly used for non-displaced fractures and severe soft tissue injuries.

Splinting involves subsequent application of a non-circumferential support held in place by an elastic bandage.

Casting involves circumferential application of plaster or fiberglass.[2]

PLASTER OF PARIS

Plaster of Paris is a hemi hydrated calcium sulphate.

To make Plaster of Paris, gypsum is heated to drive off water.[3] When water is added to the resulting powder original mineral forms and is set hard. 2(Caso4 $2H_2O$) +Heat (Caso4 1/2 H_2O) + $3H_2O$.

The name Plaster of Paris (POP) originated from an accident to a house built on deposit of gypsum near the city of Paris. The house was accidentally burnt down.When it rained on the next day, it was noted that the foot prints of the people in the mud had set rock hard. Plaster of Paris was first used in orthopaedics by Mathysen, a Dutch surgeon, in 1852. It is made from gypsum which is a naturally occurring mineral. It is commercially available since 1931.

Types of POP

Indigenous

Prepared from ordinary cotton bandage role smeared with POP powder.

COMMERCIAL

Plaster of Paris rolls commercially prepared consists of rolls of muslin stiffened by starch POP powder and an accelerator substance like alum. This commercial preparation sets very fast and gives a neat finish unlike the indigenous ones.

Plaster bandages and splints are made by impregnating crinoline with plaster of Paris [$(CaSO_4)2H_2O$]. When this material is dipped into water, the powdery plaster of Paris is transformed into a solid crystalline form of gypsum. The bandage should remain submerged until bubbles ceases to raise. The amount of heat given off is determined by the amount of plaster applied and the temperature of the water.[4] The more plaster and the hotter the water, the more heat is generated. The temperature of the water varies as to whether slow or quick setting is required. The Plaster of Paris sets more quickly when hot water is used; as a rule a temperature of 35 degree C will provide the optimum setting time. The interlocking of the crystals formed is essential to the strength and rigidity of the cast. Motion during the critical setting period interferes with this interlocking process and reduces the ultimate strength by as much as 77%.[5] The interlocking of crystals (the critical setting period) begins when the plaster reaches the thick creamy stage, becomes a little rubbery, and starts losing its wet, shiny appearance. Cast drying occurs by the evaporation of the water not required for crystallization. The evaporation from the cast surface is influenced by air temperature, humidity, and circulation about the cast. Thick casts take longer to dry than thin ones. Strength increases as drying occurs.[6]

Factors That Affect Setting Times for Casts and Splints[7]

Factors that speed setting times

Higher temperature of dipping water

Use of fiberglass

Reuse of dipping water

Factors that slow setting times

Cooler temperature of dipping water

Use of plaster

Additives are used to alter the setting time

Three variations are available

Extra-fast setting takes 2 to 4 minutes

Fast setting takes 5 to 6 minutes

Slow setting takes 10 to 18 minutes

Advantages of POP

It is cheap

It is easily available

It is comfortable

It is easy to mould

It is strong and light

It is easy to remove

It is permeable to radiography

It is permeable to air and hence underlying skin can breathe

It is non inflammable

Standard Materials and Equipment for Splint and Cast Application[8]

Adhesive tape (to prevent slippage of elastic wrap used with splints)

Bandage scissors

Basin of water at room temperature (dipping water)

Casting gloves (necessary for fiberglass)

Elastic bandage (for splints)

Padding

Plaster or fiberglass casting material

Sheets, underpads (to minimize soiling of the patient's clothing)

Stockinette

Conditions That Benefit from Immobilization[9]

Fractures

Sprains

Severe soft tissue injuries

Reduced joint dislocations

Inflammatory conditions: arthritis, tendinopathy, tenosynovitis

Deep laceration repairs across joints

Tendon lacerations

SPLINTS

Splinting involves subsequent application of a non-circumferential support held in place by an elastic bandage. Splints are faster and easier to apply; allow for the natural swelling that occurs during the acute inflammatory phase of an injury; are easily removed for inspection of the injury site; and are often the preferred tool for immobilization in the acute care setting. Disadvantages of splinting include lack of patient compliance and increased motion at the injury site.[10]

Indications

Acute and definitive treatment of select fractures

Soft tissue injuries (sprains, tendons).

Acute management of injuries awaiting orthopedic intervention.

Advantages

Allows for acute swelling

Decreased risk of complications

Faster and easier application

Commercial splints available and appropriate for select injuries

May be static (preventing motion) or dynamic (functional; assisting with controlled motion)

Disadvantages

Lack of compliance

Increased range of motion at injury site

Not useful for definitive care of unstable or potentially unstable fractures

Splints are classified based on the movement permissible as

- Static
- Dynamic
- Serial Static
- Static Progressive

CASTS

Casting involves circumferential application of plaster or fiberglass.As such, casts provide superior immobilization, but they are more technically difficult to apply and less forgiving during the acute inflammatory stage; they also carry a higher risk of complications.[11]

Indications

Definitive management of simple, complex, unstable or potentially unstable fractures.

Severe, nonacute soft tissue injuries unable to be managed with splinting.

Advantages

More effective immobilization

Disadvantages

Higher risk of complications

More technically difficult to apply

Table 1: Commonly Used Splints and Casts

Area of injury	Type of splint	Type of cast
1 land/finger	Ulnar gutter, radial gutter, thumb spica, finger	Ulnar gutter, radial gutter, thumb spica
Forearm/wrist	Volar/dorsal forearm, single sugar-tong	Short arm, long arm
Flhnw/fnrearm	1 nng arm pnstprinr. dnuhlp sugar-tong	l nng arm
Knee	Posterior knee, off-the-shelf immobilizer	Long leg
Tibia/fibula	Posterior ankle (mid-shaft and distal fractures), bulky Jones	Long leg (proximal fracture), short leg (mid-shaft and distal)
Ankle	Posterior ankle ("post-mold"), stirrup, bulky Jones, high-top walking bool	Short leg
Foot	Posterior ankle with or without toe box, hard-soled shoe, high-top walking boot	Short leg, short leg with toe box for phalanx fracture

Source: Boyd article on Splints and Casts: Indications and Methods

Table 2: Upper Extremity Splinting and Casting Chart

Region	Type of splint/cast	Indications	Pearls/pitfatk	Follow-up/referral
Ulnar side of hand	Ulnar gutter splint/ cast	Fourth and fifth proximal/ middle phalangeal shaft fractures and select metacarpal fractures	Proper positioning of MCP joints at 70 to 90 degrees of flexion, PIP and DIP joints at 5 to 10 degrees ol flexion	One to two weeks Refer for angulated, displaced, rotated, oblique, or intra-articular fracture or failed closed reduction
Radial side of hand	Radial gutter splint/ cast	Second and third proximal/ middle phalangeal shaft fractures and select metacarpal fractures	Proper positioning of MCP joints at 70 to 90 degrees of flexion. PIP and DIP joints at 5 to 10 degrees ol flexion	One to two weeks Refer for angulated, displaced, rotated, oblique, or intra-articular fracture or failed closed reduction
Thumb, first metacarpal, and carpal bones	Thumb spica splint/ cast	Injuries to scaphoid/ trapezium Nondisplaced, nonangulated, extra-articular first metacarpal fractures Stable thumb fractures with or without closed reduction	Fracture of the middle/ proximal one third of the scaphoid treated with casting	One two weeks Refer for angulated, displaced, intra-articular, incompletely reduced, or unstable fracture Refer displaced fracture of the scaphoid.
Finger injuries	Buddy taping	Nondisplaced proximal/ middle phalangeal shaft fracture and sprains	Encourage active range of motion in all joints	Two weeks Refer for angulated, displaced, rotated, oblique, or significant intra-articular fracture or failure to reqain full range of motion
	Aluminum U-shaped splint	Distal phalangeal fracture	Encourage active range of motion at PIP and MCP joints	
	Dorsal extension-block splint	Middle phalangeal volar plate avulsions and stable reduced PIP joint dislocations	Increase flexion by 15 degrees weekly, from 45 degrees to full extension Buddy taping permitted with splint use	
	Mallet finger splint	Extensor tendon avulsion from the base of the distal phalanx	Continuous extension in the splint for six to eight weeks is essential	
Wrist/hand	Volar/dorsal forearm splint	Soft tissue injuries to hand and wrist Acute carpal bone fractures (excluding scaphoid/ trapezium) Childhood buckle fractures of the distal radius	Consider splinting as definitive treatment for buckle fractures	One week Refer for displaced or unstable fractures Refer lunate fractures
	Short arm cast	Nondrsplaced. minimally displaced, or buckle fractures of the distal radius Carpal bone fracturot other than scaphoid/trapezium		
Forearm	Single sugar-tong splint	Acute distal radial and ulnar fractures	Used for increased immobilization of forearm and greater stability	Less than one week Refer for displaced or unstable
Elbow, proximal forearm, and skeletally immature wrist injuries	Long arm posterior splint, long arm cast	Distal humeral and proximal/ midshaft forearm fractures Nonbuckle wrist fractures	Ensure adequate padding at bony prominences	Within one week Refer for displaced or unstable fractures
	Double sugar-tong splint	Acute elbow and forearm fractures, and nondrsplaced, extra-articular Colles fractures fractures	Offers greater immobilization against pronation/Supination	Less than one week Refer childhood distal humeral fractures

DIP mdalal interphalangealj MCP = metacarpophalangeal; PIP = proximal mterphalangeal

Source: Boyd article on Splints and Casts: Indications and Methods

Table 3: Lower Extremity Splinting and Casting Chart

Region	Type of splint/cast	Indications	Pearts/pit falls	Follow-up/referral
Ankle	Posterior ankle splint ("post-mold")	Severe sprains Isolated, nondtsplaced malleolar fractures Acute foot fractures	Splint ends 2 inches distal to fibular head to avoid common peroneal nerve compression	Less than one week Refer for displaced or multiple fractures or significant joint instability
Ankle	Stirrup splint	Ankle sprains Isolated, nondisplaced malleolar fractures	Mold to site of injury for effective compression	Less than one week
Lower leg, ankle, and foot	Short leg cast	Isolated, nondtsplaced malleolar fractures Foot fractures—tarsals and metatarsals	Compartment syndrome most commonly associated with proximal mid-tibial fractures, so care is taken not to over-compress Weight-bearing status important; initially non-weight bearing with tibial injuries	Two to four weeks Refer for displaced or angulated fracture or proximal first through fourth metatarsal fractures
Knee and lower leg	Posterior knee splint	Acute soft tissue and bony injuries of the lower extremity	If ankle immobilization is necessary, as with tibial shaft injuries, the splint should extend to include the metatarsals	Days
Foot	Short leg cast with toe plate extension	Distal metatarsal and phalangeal fractures	Useful technique for toe immobilization Often used when high-top walking boots are not available	Two weeks Refer for displaced or unstable fractures

Source: Boyd article on Splints and Casts: Indications and Methods

APPLICATION OF SPLINTS AND CASTS

Upper Extremity Splints and Casts

Ulnar Gutter Splint

The splint begins at the proximal forearm and extends to just beyond the distal interphalangeal (DIP) joint. Cast padding is placed between the fingers.[12]

Fig. 1: Ulnar gutter splint with underlying stockinette and circumferential padding.

Source: Boyd article on Splints and Casts: Indications and Methods

Fig. 2: Ulnag gutter cast.

Source: Boyd article on Splints and Casts: Indications and Methods

ULNAR GUTTER CAST

Ideally, the cast is applied 24 to 48 hours or more after the initial injury to allow swelling to decrease. Placement of the casting materials is similar to that of the ulnar gutter splint, except the plaster or fiber glass is wrapped circumferentially.

RADIAL GUTTER CAST

The splint runs along the radial aspect of the forearm to just beyond the DIP joint of the index or fiberglass is wrapped circumferentially. The cast is usually placed two to seven days after the initial injury to allow for resolution of swelling.[13]

Fig. 3: Radial gutter cast.

Source: Boyd article on Splints and Casts: Indications and Methods

THUMB SPICA CAST

The cast uses the same position of function as described for a thumb spica splint, but requires circumferential application of casting materials.

Fig. 5: Thumb spica cast.

Source: Boyd article on Splints and Casts: Indications and Methods

THUMB SPICA SPLINTS

The splint covers the radial aspect of the forearm, from the proximal one third of the forearm to just distal to the interphalangeal joint of the thumb, encircling the thumb.

Fig. 4: Padded thumb spica splint.

Source: Boyd article on Splints and Casts: Indications and Methods

Buddy taping (dynamic splinting)

The injured finger is taped to the adjacent finger for protection and to allow movement.

Dorsal Extension Block Splint

In reduced, volar avulsion fractures, the splint is applied with the PIP joint at 45 degrees of flexion and secured at the proximal finger, allowing flexion at the PIP joint. With weekly lateral radiography, the flexion is decreased 15 degrees until reaching full extension over four weeks. Buddy taping should follow. Treatment of reduced PIP joint dislocations is similar, but requires a starting angle of 20 degrees.[14]

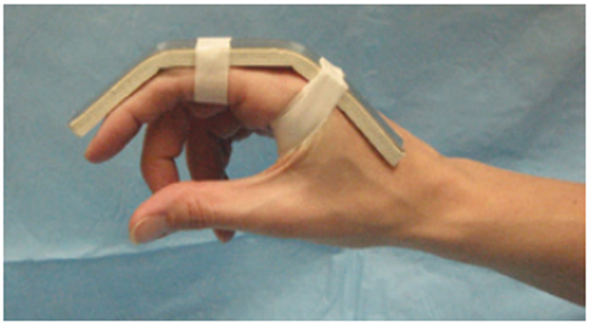

Fig. 6: Dorsal extenion block splint.

Source: Boyd article on Splints and Casts: Indications and Methods

Aluminum U shaped Splint

The aluminum splint wraps from the dorsal fingertip around to the volar fingertip and immobilizes only the DIP joint in extension.

Mallet Finger Splint

The DIP joint is placed in slight hyperextension with a padded dorsal splint, an unpadded volar splint, or a prefabricated mallet fingersplint. Continuous extension in the splint for six to eight weeks is essential, even when changing the splint. Compliance is assessed every two weeks. Night splinting for an additional two to three weeks is recommended.[15]

Volar/Dorsal Forearm Splint

The splint extends from the dorsal or volar mid-forearm to the distal palmar crease.

Short Arm Cast

The cast extends from the proximal one third of the forearm to the distal palmar crease volarly and just proximal to the MCP joints dorsally.

Single Sugar Tong Splint

The splint extends from the proximal palmar crease, along the volar forearm, around the elbow to the dorsum of the MCP joints.

Long Arm Posterior Splint

The splint extends from the axilla over the posterior surface of the 90-degree flexed elbow, and along the ulna to the proximal palmar crease.[16]

Long Arm Cast

The cast extends from the mid-humerus to the distal palmar crease volarly and just proximal to the MCP joints dorsally.

Double Sugar Tong Splint

Physicians should start by placing a single sugar tong splint. A second sugar tong splint is then applied, extending from the deltoid insertion distally around the 90 degree flexed elbow, and proximally to 3 inches short of the axilla.[17]

LOWER EXTREMITY SPLINTS AND CASTS

Posterior ankle splint ("Post-mold")

The splint extends from the plantar surface of the great toe or metatarsal heads along the posterior lower leg and ends 2 inches distal to the fibular head to avoid compression of the common peroneal nerve.

Stirrup Splint

The splint extends from the lateral mid-calf around the heel, and ends at the medial mid-calf. The position of function is with the ankle flexed to 90 degrees (neutral).

Short Leg Cast

The cast begins at the metatarsal heads and ends 2 inches distal to the fibular head. Additional padding is placed over bony prominences, including the fibular head and both malleoli.[18]

Toe Plate Extension

A plate is made by extending the casting material beyond the distal toes, prohibiting plantar flexion and limiting dorsiflexion.

Posterior Knee Splint

The splint should start just below the gluteal crease and end just proximal to the malleoli.

Complications of Splints and Casts[19]

Compartment syndrome

Ischemia

Heat injury

Pressure sores and skin breakdown

Infection

Dermatitis

Joint stiffness

Neurologic injury

CONCLUSION

Splinting involves subsequent application of a non-circumferential support held in place by an elastic bandage. Casting involves circumferential application of plaster or fiberglass. Both splints and casts have its own advantages and disadvantages. Once the need for immobilization has been determined, the physician must decide appropriately whether to apply a splint or a cast.

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