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Original Research Article.

Role of Indigenous VAC System in Management of Crush Foot Injury in a Rural Setting

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ABSTRACT

Crush injury to any part of the body in a rural setting possess its own challenges in its management calling for economical and innovative modalities. Crush injuries are on the increase globally more so in India. Wound management in such cases calls for indigenous or modern techniques in a modified manner are to be used for early and optimal crush injury management to include applied bio-mechanics, Vacuum Assisted Closure (VAC), Split Skin Graft (SSG), with customized orthosis and prosthesis. Vacuum Assisted Closure (VAC) therapy has come a long way for optimizing wound management and was used for 10 cases for foot crush injuries to suit the local milieu.

Keywords: Crush Foot Injury, Vacuum Assisted Closure (VAC) Therapy, NPWT (Negative Pressure Wound Therapy), Prosthesis, Orthosis, Surgical Rehabilitation.

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INTRODUCTION

Vacuum Assisted Closure (VAC) therapy has been used with different nomenclatures eg. NPWT (Negative Pressure Wound Therapy) etc. Globally there is increasing incidence of trauma, crush injuries due to various reasons. Amongst them the crush to the lower limb exceeds the upper limbs. In spite of early and energetic management of crush injuries, more so in the rural setting, often amputation is the only best option. Surgical management is only one facet in such cases. It is imperative to include other sciences for early and optimal outcomes which were done in this case. 10 cases who sustained crush foot injury are projected who were given the benefit of the VAC therapy. (Fig 1). VAC therapy can be given to individuals for both, those with external / internal fixators and also amputees.[1] The rural setting with the backdrop of a lack of good social security system in India, it was imperative to give a "modified" input of modern technology at each level for optimal end-result.

MATERIALS & METHODS

10 cases who sustained crush foot injury were given the benefit of the modified VAC to suit the rural settings in view of the financial status. The modified system was also applied for such cases including amputees where amputation of the foot was the only salvage option, and calling for SSG.[2,3]

In crush injury cases, the VAC system pre-op resulted in healthy granulation tissue[4-6] using the "modified" VAC therapy (Fig 2-4). The wound was covered by SSG and post-op VAC therapy was continued for early SSG anchorage and maturation (Fig 5-7). Demographic details of the ten patients as per as tables below.

The modified VAC therapy system envelopes the basics of the bio-engineering elements as seen in the branded equipment to include the "air-tight" wound site applicator, intermittent vacuum creating system and the connector tubing system. In the foot crush injury cases a thick plastic bag gave the required vacuum environment (as the foot is at the end of the limb) and tubing included a thick tube near the wound site / Ryle's tube and the central vacuum piping with decanter was used to regulated the negative pressure of the wound healing apparatus (Fig 8).

In amputees at the tarsal levels (Lisfranc's and Choprat's) due to the altered bio-mechanics with the amputation of the fore-foot the unopposed action the Gastrocnemius-Soleus complex on the residual foot there a often possibility of progressive equinus deformity of the foot at a later stage. Anticipating this, while doing the SSG, percutaneous Tendo Achilles TA lengthening was done by the standard 3 incision method using a 11 No. blade and giving a posterior Plaster of Paris slab (POP). After 2 weeks the POP slab was replaced by a "customized" ankle-foot orthosis which had

a cushioned heel with "medial and lateral uprights" using PP thermoplastic material (Fig 9). As part of the rehabilitation process in the 2nd phase the immediate post-op orthosis was replaced by customized "anchored heel-cup" with cushion for early ambulation. The cup was so fabricated that the distal wound covered with SSG was contact free so that the normal maturation of the anchored SSG was taken care of and no shearing force was experienced by the wound area as it would comprise the healing process. After about 4-6 weeks when the SSG was well taken the individual was provide by customized "partial foot" prosthesis. The "partial foot" prosthesis was in form of a "slip-in insole with toe-cushion" design which could easily be interchanged with any befitting choice of normal foot wear (Fig 10). Thus this customized amputee rehabilitation approach not only took care of the fit, and function of the amputee requirement but also the "fashion" element depending on the vocation and social events. With no "branded" devices present in rural area both the VAC equipment and the fabricated orthosis and prosthesis were locally and economically made keeping the basic bio-mechanics and biomedical-engineering principles at the fore-front. With the final prosthesis provided, the very next day he was in his old job and in the main stream of the society.

Fig 1: X-ray of Crush injury foot.

Fig 2,3: The "air-tight" enclosure for the modified indigenous VAC with "end applicator & absorbing" dressing" and "tubing" system.

Fig 4: X-ray showing the VAC system in situ (vacuum applied at the "open" wound site pre & post SSG).

Fig 5: The complete modified VAC system

Fig 6: Wound prepared by VAC system for good granulation tissue bed and SSG anchored to the open wound.

Fig 7: Post-op 7th day - Maturing SSG (with 100% uptake in the graft).

Fig 8: Post-op 4 weeks. Fully matured SSG and residual foot ready to bear weight for ADLs.

Fig 9: Design and donning of the Ortho-prosthesis; PP uprights for ankle stability and sole pad (of MCR) for ADLs. The 2nd phase of rehabilitation with customized ortho-prosthesis. Note the gap between the SSG distal end of residual foot and the front upturned MCR sheet to allow maturation of SSG on the distal part of the residual foot.

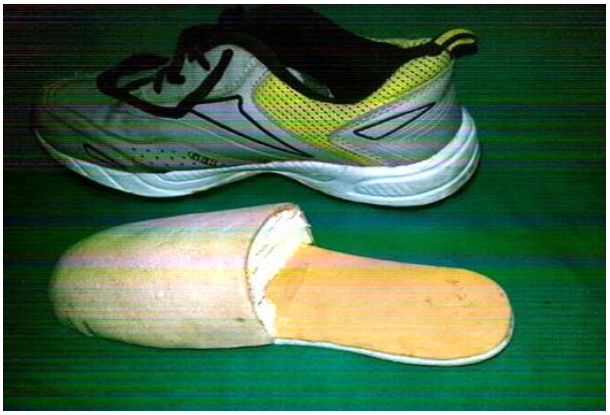

Fig 10: Final "In-sole Slip-in Partial Foot" Prosthesis & can be used with any conventional foot-wear

RESULTS

The customized approach to management of the 10 crushed foot injury cases incorporating the surgical intervention due to the altered biomechanics to address possible late deformity, the locally designed VAC therapy device and dynamic change in the fabricated orthosis and prosthesis for a continuous and dynamic treatment and rehabilitation.

This resulted in a residual foot with also normal action for any required vocational or social setting. Maintaining the maximum possible plantar aspect of the foot resulted in optimal activity even without the "end prosthesis" so that "in-house" Activity of Daily Living (ADLs) can be done with great ease. In the amputees, the final fashion of amputee and prosthesis resulted in optimal and good fit, function and fashion.

Table 1: Demographic details

		No. of patients
Age (Years)	**10-20**	**1**
	21-30	**2**
	31-40	**2**
	41-50	**3**
	51-60	**1**
	61-70	**1**
Sex	**Male**	**7**
	Female	**3**

Table 2: Crush Foot Injury

No.	Age/Sex	Etiology of Crush Injury	Site	Remarks Associated injuries
1	**45/M**	**Fall from Bus during deboarding**	Right Foot	With C.L.W. Rt. Forearm with head injury (concussion)
2	**19/F**	**Fall Tractor & Wheel passed over**	Right Foot	Anterior Cruciate lig Injury (Rt.)
3	**28/M**	**Machinery Industry**	Left Foot	Abrasions on Back
4	**35/M**	**RTA by Motor Cycle**	Left Foot	C.L.W. Over face
5	**24/F**	**Motor Cycle Wheel Injury**	Right Foot	-
6	**49/M**	**Train Accident**	B/L Foot	Lt Supracondylar #
7	**51/M**	**RTA Truck Wheel passed over**	Left Foot	-
8	**43/M**	**Fall From Height**	Right Foot	Patella (Rt.) #
9	**62/F**	**RTA Tanga Accident**	Right Foot	Chest Injury with 5^{th} , 6^{th} , 7^{th} Ribs #
10	**33/M**	**Agriculture Harvesting Wheat**	Right Foot	-

Table 3: Site Distribution

Right Foot	Left Foot	B/L Foot
6	3	1

Table 4: Isolated / Associated Injury Distribution

Isolated Foot Injury	Associated with other Injuries
4	6

DISCUSSION

Globally there is increase in the incidence of trauma with varying backgrounds, moreover the lower limb injury are more than the upper limb injuries. Of course the first line of management is to salvage the whole limb but often the only best option is amputation more so in the rural areas due to various factors.[7-9] This has to be followed by rehabilitation wherein the appropriate orthosis and or prosthesis come to play a major role.

Like in the hand, all attempts are always made in crush injury foot, for primary repair with maximum plantar length. However, very often, this may call for adjuvant plastic procedures right from SSG to various types of flap procedures including "fillet" flap.[10] Considering the function of the foot the integrity of the plantar aspect is of prime importance. A good partial foot amputation stump often demands that the distal end for the stump be covered by the plantar layer of the foot and should be undertaken where there is no significant compromise with the new residual foot plantar surface area. However this becomes difficult in proximal levels of partial foot amputation like Lisfranc's and Chopart's amputation.[11]

VAC / NPWT efficiency was proven in 1993 on animal models.[4] After few years it took a clinical turn and the concept has be widely used since then taking different nomenclatures.[5,6] Today VAC technique has evolved as a "alternative" method to treat certain wounds / ulcers.

VAC therapy has become a standard modality of wound management in both routine and difficult cases and complimentary to various surgical procedures. VAC technique can be successfully used in wounds of complex ulcers due to the local "altered induced local patho-physiology and augmented healing dynamics".[4-6]

Patients with crush injury foot were treated using the "VAC Technique" developed locally and was very effective. The low illiteracy state of the patient and that of the bed-side attendant / relative was taken into consideration with the ultimate aim of empowering the patient for strict adherence to the treatment regime. A suitable VAC technique protocol was developed. Negative pressure of 120-130 mm Hg was applied for cycles of 10 minutes each - 6 minutes vacuum followed by an interval of 4 minutes rest. The commercially available VAC apparatus, with prototypes manufactured abroad are very costly for most patients in any developing country more so in a rural setting. To keep the cost low, "in-house" vacuum system including, tubing and "end-vacuum applicator" was fabricated which was linked with the central vacuum line of the hospital. This modified and economical VAC system was used for this patient both pre and post op in an effective way wound being at the terminal part of the limb it was easy to secure the vacuum system to have a good and continuous vacuum (Fig 5).

For early rehabilitation to include standing, ambulation and ADLs initial use of orthosis for stability of the partial foot amputation is imperative and there are multiple choices due to the material used and designs available. Materials used can be leather, thick fabric, or thermoplastic materials. The role of prosthesis increases as the level gets proximal and may lead to special footwear-like prosthesis. To have good weight distribution often a cushioning material like form, Micro Cellular Rubber or silicon sheet is used – this also takes care of the foot deformity, if any.

SUMMARY

10 cases of crush injury foot were treated in a rural medical institution setting with all possible modern wound management techniques. The management included VAC therapy given, (which was pre-SSG, and in the post-op period) resulting in good healing of tissue including the SSG. Post-op rehabilitation was undertaken by use of be-fitting orthosis and prosthesis which resulted in early re-entry into the main stream of society. At each stage suitably technology was modified to fabricate innovating and economical devices to meet the financial viability and activities of the patient.

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