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## Case Report

# Combination of negative pressure wound therapy (NPWT) and integra dermal regeneration template (IDRT) in the lower extremity wound; Our experience with 4 cases

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## ABSTRACT

The treatment of de-gloving injuries in the lower limb with exposed tendons, bone, and/or nerve is a challenging reconstruction problem. The standard management of de-gloving injuries involve either direct closure if the skin is viable or immediate grafting with the avulsed skin or full- or split-thickness graft when the skin flap is not viable. Alternative methods are flap coverage especially when the underlying structures are not suitable for grafting such as extensive loss of paratenon and/or exposed bone or open joints. The use of negative pressure wound therapy (NPWT) followed by use of Integra dermal regeneration template (IDRT) and subsequent split-thickness skin grafting (STSG) as an alternative to the previously mentioned surgical options has been described. In this series we describe the successful management of four patients with exposed tendons, bones, and joints of the distal lower extremity following road traffic accidents (RTA) using NPWT, Integra and thin split-thickness skin grafts.

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## Introduction

The treatment of complex distal lower limb wounds is challenging and technically demanding for reconstructive surgeons. There are many well-established protocols for wound management, which include primary or direct closure, grafts, local, and free flaps. However, free flaps require well-trained microsurgeons and are often only performed in specialized centers. Additionally, medical comorbidities make some patients poor candidates for a complex flap reconstruction. The use of NPWT combined with the Integra dermal regeneration template (IDRT) followed by split-thickness skin grafting (STSG) as an alternative to complex flap reconstruction has been described previously.<sup>1</sup>

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. Despite its many modifications, several major advances in wound healing and reconstruction have yet to be incorporated into the ladder. In particular, the use of negative-pressure wound therapy and dermal matrices, both of which have wide clinical application.<sup>2–5</sup>

Integra dermal regeneration template (IDRT) (Johnson & Johnson, Hamburg, Germany) was first described in 1981 by Burke and Yanas and was approved by the Food and Drug Administration in 1996. Integra appeared for the first time commercially in 1997 and has been popularized over the past 20 years. Dermal Regeneration Template is a two-layer skin regeneration system. The outer layer is made of a thin silicone film. It protects the wound from infection and controls both heat and moisture loss. The inner layer is constructed of a complex matrix of cross-linked fibers. This porous material acts as a scaffold for regenerating dermal skin cells, which enables the re-growth of a functional dermal layer of skin. Once dermal skin has regenerated, the silicone outer layer is removed and replaced with a thin epidermal skin graft.<sup>6,7</sup>

Negative pressure wound therapy (NPWT), refers to wound dressing systems that continuously or intermittently apply sub-atmospheric pressure to the surface of a clean wound accelerating the process granulation tissue formation. Since its development in the early 1990s, NPWT has become a popular treatment modality for the management of many acute and chronic wounds.<sup>8–11</sup>

The authors present four case reports of the successful use of IDRT and NPWT followed by split skin graft in the management of complex distal lower extremity wounds following high velocity RTAs.

## Case reports

### Case 1

A healthy 10-year-old boy presented with an extensive de-gloving injury involving dorsum of the left foot with soft tissue loss and exposed tendons and bones [Figure. 1.1]. The wound was contaminated with debris, mud, and soil. There were no underlying fractures or vascular injuries. Following debridement the resulting defect measured  $8 \times 5$  cm.

### Case 2

A healthy 22-year-old adult presented with an avulsion injury involving the dorsum of the left foot with soft tissue loss and exposed tendons [Figure. 2.1]. The wound was contaminated with debris, mud, and soil. There were no underlying fractures or vascular injuries. Following debridement, the resulting defect measured  $10 \times 6$  cm.

### Case 3

A healthy 30-year-old adult presented with an extensive de-gloving injury involving the dorsum of the left foot with exposed tendons and soft tissue loss [Figure. 3.1]. The wound was contaminated by debris, mud, and soil. Following debridement the defect measured  $12 \times 7$  cm.



**Figure 1.** (1.1) (Left photo) Post traumatic foot defect with exposed tendons and bones, (Right photo) 4 days after debridement and application of NPWT. (1.2) (Left photo) application of Integra. (Middle photo) After removal of a silicon layer and preparation for applying STSG. (Left photo) applying Split thickness skin graft (STSG). (1.3) 2 month Post-op.



**Figure 2.** (2.1) (Left photo) Post traumatic avulsion injury involving the dorsum of left foot with exposed tendons and bones. (Middle photo) After surgical debridement. (Right photo) 4 days after application of NPWT. (2.2) (Left photo) application of Integra. (Middle photo) After removal of a silicon layer and preparation for applying STSG. (Right photo) applying Split thickness skin graft (STSG). (2.3) 1 month Post-op.



**Figure 3.** (3.1) An extensive degloving injury involving the dorsum of the left foot with exposed tendons and soft tissue loss. (3.2) After surgical debridement and Integra application. (3.3) Removal of a silicon layer after 3 weeks and applying STSG. (Right photo) one week follow up after STSG.

#### Case 4

A 50 years old diabetic male patient, presented with a heavily contaminated avulsion injury involving the dorsum of the left foot and a Gustilo Type IIIA fracture of distal 1/3 of the tibia which was managed with an Ilizarov frame. Following debridement and fixation the defect measured  $8 \times 6$  cm [Figure. 4].

All patients had immediate wound excision and extensive irrigation to obtain clean wounds. Following a 'second look' procedure at 48 h and swabs taken for culture and sensitivity, NPWT was applied. All four patients had positive growths for Gram-negative organisms. Appropriate antibiotic



**Figure 4.** (upper left photo) Post traumatic degloving foot defect with exposed tendons and bones. (upper right photo) surgical debridement and integra application. (lower left photo) After removal of a silicon layer and preparation for applying STSG. (lower Right photo) 2 month follow up after Split thickness skin graft (STSG).

therapy was instigated on the advice of an infectious disease specialist and continued until the wound swabs became negative. Once sufficient granulation was established and wound swabs were negative a dermal regeneration matrix (INTEGRA®) was applied for three weeks.

After three weeks, the silicone layer was removed and a thin STSG taken from the ipsilateral thigh was applied. After two months of follow up in case one, 1 month in case two, 1 week in case 3 and 2 months in case 4, the results were satisfactory (Figures. 1,3,2,3,3,3, and 4) with complete healing achieved in all four cases.

## Discussion

Complex lower extremity traumatic defects represent a uniquely complex challenge for the reconstructive surgeon. The nature and severity of lower extremity injuries differ between military and

civilian settings and ranges widely from falls and motor vehicle collisions to blast and fragmentation injuries. Military injuries are primarily due to penetrating or combined mechanisms including blast injuries which are associated with high rates of open fracture and vascular injuries.<sup>12</sup> In contrast, most severe lower extremity injuries in civilians are due to high velocity blunt trauma.

Before the 1990s the mainstay management of lower extremity soft tissue wounds centered on surgical debridement, local wound care, and dressing application, as well as off-loading strategies to facilitate an ideal healing environment.<sup>13</sup> Delayed cover with skin grafts and flaps was the norm with high rates of infection.

More recently, emergent debridement and a focus on early closure of defects with complex flaps has reduced infection rates, reduced length of stay in hospital and shortened rehabilitation time. However, early wound closure is not always possible because complex reconstructions may not be possible or available. With the advent of NPWT and tissue engineered acellular dermal matrices, alternative 'delayed' wound closure is still possible without the high infection rates of the past. In relation to acellular dermal matrices the majority of currently available clinical data has focused on two products: Integra (Integra Life Sciences, Plainsboro, N.J.) and Graft Jacket (KCI, San Antonio, Texas).<sup>14</sup>

Integra is a well-known skin substitute and has been used in full thickness burn patients,<sup>15–17</sup> in cases of purpura fulminans complication,<sup>18</sup> in both plastic and reconstructive surgery.<sup>19,20</sup> and in the treatment of chronic wounds, contractures and bone exposure.<sup>21</sup>

The disadvantage of Integra is the necessity for a two-stage procedure and the risk of infection developing under the silicone layer. Another disadvantage is the high cost involved. However, Integra has several advantages. Firstly, it creates a neodermis over the wound which can improve scar quality and mobility following STSG. These softer more pliable scars are particularly important over joints to permit the recovery of a good range of motion. Secondly, a sophisticated procedure and free flap can be avoided. Thirdly, this technique permits a daily dressing without general anesthesia, until the final skin grafting. Fourthly, the contour of the reconstruction is less bulky than a flap which is an important consideration for later footwear.

In this small series we describe our experience with extensive de-gloving injuries to the distal lower extremity in four patients by using NPWT combined with IDRT followed by STSG. In contrast, Elmaghrabi described using Integra alone without NPWT in lower extremity wounds.<sup>5</sup> However, several studies have also reported the efficacy of using NPWT with IDRT followed by STSG in lower extremity wounds<sup>22–24</sup> and these results are consistent with our outcomes. Several reports have emphasized the value of a dermal regeneration template for the reconstruction of complex lower limb defects. Consistent with these studies, functional and cosmetic results have been superior to those obtained with skin grafts alone, which may result in impaired ankle motility.<sup>25</sup>

## Conclusion

The combined use of NPWT and IDRT, followed by split skin graft is a safe, feasible and relatively easy option to obtain long lasting and durable cover of traumatic defects in complex lower extremity wounds, with good esthetic and functional results. The choice of NPWT-IDRT-skin graft combined therapy can obviate the need for complex surgical procedures such as local flaps, and free flaps where these are not available, or patients are unsuitable for this type of complex surgery.

## Declaration of Competing Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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