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Narrative Review

Removable Rigid Dressings for Postoperative Management of Transtibial Amputations: A Review of Published Evidence

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Abstract

Forty years of clinical experience and peer-reviewed research studies support the use of nonweight-bearing removable rigid dressings (RRDs) as an effective means of postoperative management of transtibial amputations. We reviewed the published medical evidence regarding the use of RRDs as a postoperative management strategy, culminating in an evidence-based practice recommendation. Published peer-reviewed literature on the topic was searched and classified by level of evidence based on the research design using the scale recommended by the *PM&R* (level I through V). The search uncovered a total of 15 articles, including 5 level I randomized controlled trials, 6 level III retrospective matched controlled trials, and 4 level V case reports.

A number of benefits associated with the application of RRDs compared with soft dressings were reported across these 15 studies. These included faster healing times, reduced limb edema, preparatory contouring of the residual limb in anticipation of prosthetic use, the prevention of knee flexion contractures, and reduced external trauma to the limb. Also described were an increased probability of successful prosthetic use and pain reduction. The RRDs studied permitted regular inspection of surgical wounds with greater ease and consistency of application than traditional soft dressing approaches. Rigid dressings provide all the same benefits of RRDs except ease of wound inspection, therefore rendering them impractical for the 82% of patients receiving an amputation for ischemic disease that are at high risk of developing wound dehiscence. Weight-bearing immediate postoperative prostheses are almost exclusively reserved for use on trauma patients who usually do not show evidence of vascular or neurologic impairment. The inherent risks of falls and inconsistent pressure on the surgical wound have further restricted their use in practice to a limited patient type.

The benefits of RRDs compared with soft dressings are universally recognized in the published peer-reviewed medical evidence to be superior to soft dressings. Based on the best-available current published evidence, nonweight-bearing removable rigid dressings should be considered the first treatment choice for the postoperative care of transtibial amputees to optimize outcomes with regard to reductions in injury due to falls, knee flexion contractures, edema, healing time, time to prosthetic fitting, and pain.
Level of Evidence: II

Introduction

Postamputation management of the residual limb remains an integral yet often overlooked element of surgical recovery and is instrumental in achieving optimal long-term patient outcomes [1-3]. Postoperative, preprosthetic care prepares the residual limb for a more successful prosthetic fitting and earlier ambulation compared with soft dressings alone [4]. The goals of postoperative management are to provide a clean wound healing environment, reduce swelling and associated pain, protect the limb from external trauma, reduce the incidence of knee flexion contractures, reduce hospital length of stay, decrease time before casting for initial prosthesis, provide for earlier ambulation, and ultimately facilitate each person's potential for their maximum rehabilitation with a faster return to activities of daily living.

The primary dressings in use today are soft dressings, nonweight-bearing removable rigid dressings (RRDs), nonremovable rigid dressings (RDs), and weight-bearing immediate postoperative prostheses (IPOPs). RDs previously have been proven superior to soft dressings, but their contemporary use has diminished in clinical practice because of inaccessibility to the residual limb and the risk of developing wound dehiscence in patients with ischemic disease [5-7]. Thigh-level RDs, RRDs, and IPOPs split the knee in extension and protect the residual limb inside the dressing with a protective outer shell [8]. After initial enthusiasm, IPOPs were proven to

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be unsafe in most settings for patients with ischemia and are now rarely used in that population [9,10]. RRDs often are applied over soft dressings.

Despite the published evidence supporting the attributes of RRDs, a consensus has not been reached in clinical practice regarding dressing selection for the management of transtibial amputations [2]. In 2001 Choudrey et al [11] reported up the practice patterns observed across the Veterans Administration hospitals that performed transtibial amputations and found that 67% of patients who underwent transtibial amputation received soft dressings, 5% IPOP, 14% nonremovable RDs, and 14% RRDs.

Currently, choice of dressing appears to be based on training, local practice patterns, and intuition rather than medical evidence. This is likely because the medical evidence regarding RRDs has been published over many years and in varied journals across multiple disciplines, with some studies commingling the various dressings (Table 1) [12]. All the dressing types satisfy the immediate need to cleanly cover the fresh surgical incision and maintain some compression on the residual limb. The historical standard of soft dressings offers the advantage of low cost and accessibility to the wound. However, descriptive studies have observed a tendency for soft dressings to fall off, an increased probability of knee flexion contractures, the potential for proximal or uneven circumferential pressures that inhibit healing and skin survival, and greater likelihood of injury to the residual limb from external trauma [13]. Subsequent developments of postoperative dressings were designed to address these shortcomings by preventing knee flexion contractures, reducing edema, providing consistent precontouring of the residual limb, facilitating ease of patient use, and protecting against external trauma from falls [1,2,14]. The objective of the present narrative review is to examine the extant literature regarding nonweight-bearing RRDs for transtibial amputees and determine whether the body of the evidence is sufficient to support an evidence-based recommendation.

Search Strategy

Using Google Scholar, PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL), OVID, Medline, Medline plus (at National Library of Medicine), Scopus, JSTOR Search, Web of Science (ISI Citation Indexes), and Embase, we conducted a literature search using the following keyword search terms: removable rigid dressings, transtibial amputation dressings, postoperative dressings for transtibial amputees, and rigid dressings. The search was not constrained by search dates but was limited to human studies published in the English language. No methodologic filters were applied to limit retrieval by study type. A manual search of the bibliographies from extracted studies was conducted to identify studies not captured in the electronic database searches. All authors' names on relevant identified articles were searched to further mitigate the possibility of inadvertently omitting any published work on the topic. All articles identified by the search are included in this review.

Assessment of the Literature

The body of published peer-reviewed literature regarding RRDs revealed by our search consisted of 5 level I randomized controlled trials (RCTs), 6 level III retrospective matched controlled trials, and 4 level V case reports (Table 1) [12]. Although the RRD initially was described in a textbook chapter, the clinical maneuver was not technically studied and published until the following year [13]. In 1979, the first peer-reviewed published work on the intervention was a retrospective matched controlled trial that compared 19 patients experiencing 21 transtibial amputations treated with a RRD compared with 30 patients treated at the same medical center with similar surgical technique but with conventional soft dressings postoperatively [15]. Wu et al [15] demonstrated RRDs compared with soft dressings had 57.8% faster average "time to healing," as measured by the time from amputation to initial casting for definitive prosthesis, and 46.8% faster average "time to rehabilitation," as measured by date of discharge on prosthesis. In addition, the authors described how the removable nature of the RRD permitted frequent observation and progressive shrinkage of the residual limb while maintaining the advantage of immobilization of soft tissue to reduce pain and prevent external trauma to the residual limb. RRDs also significantly reduced the incidence of skin breakdown and distal edema, which facilitated earlier hospital discharge.

Superiority of the RRD versus soft dressings was subsequently confirmed by a RCT that included 15 patients with 16 amputations due to vascular disease [16]. The RRD group had a significant decrease in volume from a mean change of zero ($t = 9.35$, $P < .0005$). The authors also reported that the RRD group experienced significantly greater reductions in residual limb volume compared with the elastic bandage group ($t = 2.09$, $P < .05$). The RRD was also described as providing symmetrical shaping forces to the limb without creating localized pressure areas and could be independently applied by patients. The authors speculated that a well-shaped limb would enhance the overall prosthetic-wearing experience.

Three case reports were published next. These case reports were published at an important time in the development and acceptance of RRDs in that they served to allay fears that extreme caution should be exercised before applying RRDs to patients with either wound healing challenges or manual dexterity limitations. The initial case report described 2 individual patient cases. A 53-year-old woman was admitted to the rehabilitation hospital with a swollen, edematous, and

Table 1
Medical evidence using RRDs for patients with transtibial amputations

Study	Level of Evidence	N	Research Design	Population Studied	Dressing Studied	Principal Findings/Reported Outcomes
Wu et al, 1979 [15]	III	21	Matched cohort	19 men with BKA	Experimental group: BK plaster cast held by a suspension stockinette to a supracondylar plastic cuff Control Group: SD	57.8% faster average time to healing and 46.8% faster time to rehabilitation with RRD vs SD.
Mueller et al, 1982 [16]	I	16	RCT	10 men, 5 women +55 y BKA <2 mo, vascular disease	Experimental group: modified Wu dressing Control group: elastic bandage	RRD showed significantly greater residual limb shrinkage compared with SD ($t = 2.09$, $P < .05$). RRD had a significant decrease in volume from a mean change zero ($t = 9.35$, $P < .0005$).
Gandhavadi et al, 1987 [17]	V	2	Case report	53-y-old woman, diabetic, 62-y-old man with PAD	Modified Wu dressing	Female - unhealed wound; 3 wk after RRD completely healed wound, residual limb shaped and conditioned for prosthesis. Male - unhealed wound, 3 wk after RRD the wound healed and limb shrinkage and shaping took place. RRD maintains advantaged of rigid dressings and allows wound inspection.
Richter et al, 1988 [18]	V	1	Case report	68-y-old man, diabetic	Modified Wu dressing	6 wk after the RRD was applied, the patient had complete wound healing. RRD proved ideal for a residual limb with poor wound healing.
Gendron et al, 1991 [19]	V	1	Case report	9-y-old boy, traumatic	Modified Wu dressing	35 d after the injury, a RRD replaced SD. 14 d later, complete wound healing occurred. The RRD is a beneficial technique for the preprosthetic management of the juvenile amputee.
Hughes et al, 1998 [20]	III	NR	Matched cohort	Uncomplicated BKA	Experimental group: Modified Wu dressing Control group: SD	RRD significantly reduced time to fitting of definitive prosthesis from 101 to 46 d. Residual limb injury decreased from 22% to 0%.
Duetsch et al, 2005 [22]	I	41	RCT	BKA vascular disease	Experimental group: modified Wu dressing Control group: standard SD	Primary wound healing of the residual limb occurred almost 2 wk earlier in patients with RRD (RRD = 51.2 d ± 19.4; SSD = 64.7 d ± 29.5 d; $P = .07$; RRD: n = 17; SSD: n = 14).
Tsai et al, 2007 [24]	V	1	Case report	89-y-old man, PVD	Customized polyethylene RRD	Authors observed improved wound healing and the patient reported less phantom pain.
Ladenheim et al, 2007 [25]	III	104	Matched cohort	BKA	Experimental group: prefabricated polyethylene RRD Control group: SD	Patients with RRD casted for initial prosthesis an average of 58.4 d (SEM), ± 3.6 d) postsurgery vs 84.4 (SEM ± 7.9 days) with SD, $P = .001$).

Johannesson et al, 2008 [26]	I	27	RCT	Patients undergoing BKA for PVD	Experimental group: vacuum-formed RD Control Group: rigid dressing of plaster of Paris	Mean time to prosthetic fitting 37 (26-54) d in the RRD group vs 34 (21-47) days in the rigid dressing group (adjusted mean difference 3, 95% CI −3 to 9). RRDs give results similar to RDs while allowing frequent wound inspection.
Taylor et al, 2008 [27]	III	65	Matched cohort	Dysvascular patients receiving BKA	Experimental group: modified Wu dressing Control group: conventional SD	Mean time to casting with a RRD 27.6 (21.2-32.7) d vs 36.4 (24.0-50.0) in the non-RRD group ($P < .05$). Acute length of stay 15.9 in the non-RRD group vs 8.7 days in the RRD group ($P < .001$). RRD significantly reduced acute LOS and time to first prosthetic casting.
Janchai et al, 2008 [28]	I	26	RCT	11 men, 15 women average age 68 y, 80% vascular indications	Experimental group: modified Wu dressing Control group: elastic bandage	Tendency to reduce residual limb volume at two weeks 42.73 ± 62.70 cm^3 in the RRD group vs 21.89 ± 118.49 cm^3 in the elastic bandage group ($P = .064$). Residual limb volume reduced faster with use of RRD compared with SD. Decreasing volumes were not different at 4 wk.
Duwayri et al, 2012 [29]	III	100	Case series/matched cohort	66 men and 34 women BKA >18 y	Layer of soft stockings and a compressive gel liner under a rigid removable, custom-designed shell. Experimental group: compliant patients Control group: noncompliant patients	Compliant patients more likely to be fitted with prosthesis (72 vs 42%, $P = .005$). Greater number of compliant patients fitted 100 days postamputation (69.7 vs 22.2%, $P = .012$).
Hidayati et al, 2013 [30]	I	23	RCT	BKA dysvascular indication	Experimental group: modified Wu dressing Control group: elastic bandage	Decrease in edema at 2 wk 63.85% in the RRD group vs 34.35% in the SD group ($P = .01$). Significant decrease in residual limb volume and a nonsignificant tendency toward pain reduction.
Sumpio et al, 2013 [31]	III	151	Matched cohort		Experimental group: prefabricated polyethylene RRD Control group: SD	Median time to heal was 76 d for patients in a RRD compared with 127 in the SD group ($P = .02$). The percentage of patients casted at 60 d was 58.24% in the RRD group and 38.33% in the control ($P = .03$). RRD patients had a significantly quicker healing time and faster time to be cast for first prosthesis.

Based on the levels of evidence definitions used by *PM&R*.

RRD = removable rigid dressing; BKA = below-knee amputation; BK = below knee; SD = soft dressing; RCT = randomized controlled trial; PAD = peripheral artery disease; SSD = standard soft dressing; PVD = peripheral vascular disease; SEM = standard error of the mean; CI = confidence interval; LOS = length of stay.

tender residual limb with a 4-cm opening in the surgical incision after 3 weeks in a traditional soft dressing. A RRD was applied, and within 2 weeks the surgical wound was healed and the residual limb was conditioned and shaped. The second patient was a 62-year-old man admitted to the same hospital with a residual limb that was red, swollen, and tender with a 2-cm open area in the surgical incision over the lateral aspect. Three weeks after applying a RRD, the author observed reduction in the size of the residual limb, improved shaping, and the surgical incision healed well [17].

The second case report published described successful use of a RRD in obtaining wound closure for a patient with severe wound dehiscence [18]. The authors concluded the technique was ideal for a residual limb with poor wound healing while providing protection of the limb and better shrinkage combined with the ability to remove the dressing, examine the wound and treat if necessary. The third case report described a traumatic amputee in which the use of a RRD over 14 days facilitated wound closure for a juvenile who had experienced delayed healing for 35 days before the intervention [19]. This latter case was notable in that the authors observed that the RRD provided wound protection during ambulation, normal childhood playing, and mat exercises.

In 1998, a second retrospective case controlled trial further compared outcomes between RRDs and soft dressings [20]. The authors reported that the average time for fitting of definitive prosthesis was reduced by 55% for those managed with a RRD and the annual incidence of external trauma to the residual limb decreased from 22% to zero. This reduction in external trauma to the residual limb as a result of falls was confirmed in a later study that demonstrated a similar decline from 17% to zero with the use of a RRD [21].

These observations were followed by a RCT composed of 22 patients receiving a RRD and 19 patients receiving standard soft dressings [22]. For those subjects managed with an RRD, primary wound healing of the residual limb occurred nearly 2 weeks earlier than those managed with soft dressings; this, however, was not statistically significant (51.4 days versus 64.7 days; $P = .07$). This study also confirmed the earlier findings of enhanced protection from falls. Proponents of RRDs wrote a letter to the editor after this study. They questioned the feasibility of an RCT to show dramatic differences from soft dressings because of cofounders, such as hospital procedure, surgical technique, and postamputation rehabilitation program [23].

This was followed by yet another case report describing an 89-year-old man who had sustained frequent falls in the bathroom of a rehabilitation hospital, leading to residual limb wound dehiscence. After a polyethylene RRD was applied, the patient had better limb protection and demonstrated improved wound healing while reporting less phantom pain [24].

A multicenter retrospective cross-sectional study compared 76 patients treated with a prefabricated RRD with 28 patients receiving soft dressings [25]. Consistent with previously reported results, those patients managed with the prefabricated RRD were casted for their first custom prosthesis an average of 26 days sooner than those in the soft dressing group (58.4 days versus 84.4 days; $P = .001$). Citing this statistically significant improvement, authors concluded that wound healing was improved with a RRD (Figure 1).

Researchers next sought to determine equivalency between RDs and RRDs by performing an RCT, since RDs were already well accepted by clinicians as superior to soft dressings and producing beneficial outcomes in the transtibial amputee. This is the only published study comparing RRDs with RDs. This study demonstrated the mean time to prosthetic fitting of 37 (26-54) days in the RRD group compared favorably with 34 (21-47) days in the RD group (adjusted mean difference 3, 95% confidence interval −3 to 9). Three months postamputation, the researchers measured each patient with the Locomotor Capability Index and the Timed "Up and Go" test and found both groups performed equally. The authors concluded the RRD appears to give results similar to those of conventional RDs regarding time to prosthetic fitting and patient's function with prosthesis [26].

An additional retrospective case-note audit composed of 28 subjects in a RRD group and 37 in a non-RRD group demonstrated that the application of RRDs significantly reduced acute hospital length of stay (15.9 days versus 8.7 days, $P < .001$) and time to first prosthetic casting (36.4 days versus 27.6 days, $P < .05$) [27]. The RRD thus provided substantial benefits in preparing the transtibial amputee for early rehabilitation and prosthetic intervention.

A subsequent RCT provided a comparison between RRDs and elastic bandages in reducing limb volume of below-knee amputees [28]. RRDs had a tendency to reduce residual limb volume faster than elastic bandages at 2 weeks; however, the study found no statistically significant differences between the 2 groups at 2 and 4 weeks postoperatively. The limb volume reduction for the RRD versus elastic bandage was 42.73 ± 62.70 cm^3 versus 21.89 ± 118.49 cm^3 at 2 weeks and 79.9 ± 103.33 cm^3 versus 83.03 ± 113.05 cm^3 at 4 weeks.

A retrospective cohort study then compared 76 patients who were compliant with an RRD with 24 who were not [29]. Compliant patients were significantly more likely to be successfully fit with a prosthesis (72% versus 42%, $P = .005$). A clinically important discovery of this study is that RRD use was found to be associated with earlier and more frequent use of prosthesis (Figure 2).

In another RCT that included 23 patients, those treated with an RRD experienced accelerated limb volume reduction rates in the first 2 weeks compared with those with soft dressings—a 63.85% reduction for the RRD group versus 34.35% for the soft dressing group

Figure 1. FLO-TECH-TOR prefabricated polyethylene removable rigid dressing used in the Ladenheim et al [25] and Sumpio et al [31] studies. Courtesy of FLO-TECH O&P Systems, Inc.

Figure 2. AmpuShield removable rigid dressing. Predicate device used in the Duwayri et al [29] study. Courtesy of Hanger Clinic.

($P = .01$). After 3 weeks, decreases in residual limb edema were not statistically different; however, those improvements observed in the first 2 weeks can have a valuable impact on initial wound healing and therefore speed up limb maturation. The residual limb was free of edema at week 5.08 $\pm$ 1.17 in the RRD group versus week 6.82 $\pm$ 1.31 in the elastic bandage group, which was statistically significant ($P = .03$) [30].

More recently, the authors of a 151-patient retrospective, cross-sectional study compared the outcomes with RRDs or RDs against those with soft gauze dressings and knee immobilizers [31]. This largest study to date demonstrated significantly quicker healing times, as measured by time to be cast for initial prosthesis. After the first 60 days, the percentage of patients ready to be cast was significantly greater in the RRD and RD group compared with the soft-dressing group (58.24% versus 38.33%; $P = .03$) (Figure 1).

Discussion

RRDs were originally designed to provide all the advantages previously reported for the IPOP and rigid cast dressings while eliminating the disadvantages of lack of access to the wound site and the potential for excessive weight bearing, particularly troublesome for patients receiving an amputation due to vascular disease. Among the cited benefits of RRDs is reduced incidence of fall-related trauma to the residual limb. Falls are both a common and potentially catastrophic occurrence after lower limb amputation, often resulting in lacerations, fractures, wound dehiscence, and additional damage to the limb that may require revision surgery [32-36]. Many patients with lower limb amputations experience difficulty retaining balance and as a result represent the subset of patients most likely to fall during inpatient stay (20.6%) [32]. Approximately one third of all lower limb amputee admissions are complicated by an accident; most represent falls. In the general hospitalized population, injurious falls have been proven to be associated with prolonged hospital stay [21,37]. In their assessment of postoperative RRDs Gooday and Hunter [21] observed that they "are straightforward to apply, well tolerated, and inexpensive so it may be appropriate to consider using them more widely." Corroborating evidence by Hughes et al [20] showed a decrease in the annual incidence of injury to the residual limb from 17% to zero as result of introducing RRDs as a standard of care for postoperative management of transtibial amputations.

A recent study entitled "Do Rigid Dressings Reduce the Time From Amputation to Prosthetic Fitting? A Systematic Review and Meta-Analysis" confirmed the faster time to prosthetic fitting demonstrated in the studies with small

sample sizes [4]. A subsequent letter to the editor clarified the potentially misleading title by pointing out that 4 of the 6 trials that met the strict entry criteria actually examined RRDs [38]. The authors wanted readers to realize that clinicians could apply RRDs, which provided the identical advantages as RDs while maintaining the ability to easily inspect and treat the surgical wound.

Conclusion

The benefits of RRDs are universally recognized in the published peer-reviewed medical evidence to be superior to soft dressings. Based on the best-available current published evidence, RRDs should be considered the first treatment choice for the postoperative care of transtibial amputees to optimize outcomes with regard to reductions in injury due to falls, knee flexion contractures, edema, healing time, time to prosthetic fitting, and pain.

References

1. Smith DG, McFarland LV, Sangeorzan BJ, Reiber GE, Czerniecki JM. Postoperative dressing and management strategies for transtibial amputations: A critical review. J Rehabil Res Dev 2003;40:213-224.
2. Nawijn SE, van der Linde H, Emmelot CH, Hofstad CJ. Stump management after trans-tibial amputation: A systematic review. Prosthet Orthot Int 2005;29:13-26.
3. Smith D. General principles of amputation surgery. In: Smith D, Michael J, Bowker J, eds. Atlas of Amputations and Limb Deficiencies: Surgical, Prosthetic, and Rehabilitation Principles. 3rd ed. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2004, 27-28.
4. Churilov I, Churilov L, Murphy D. Do rigid dressings reduce the time from amputation to prosthetic fitting? A systematic review and meta-analysis. Ann Vasc Surg 2014;28:1801-1808.
5. Woodburn KR, Sockingham S, Gilmore H, et al. A randomized trial of rigid stump dressing following trans-tibial amputation for peripheral arterial insufficiency. Prosthet Orthot Int 2004; 28:22-27.
6. van Velzen AD, Nederhand MJ, Emmelot CH, et al. Early treatment of trans-tibial amputees: Retrospective analysis of early fitting and elastic bandages. Prostet Orthot Int 2005;29:3-12.
7. Mooney V, Harvey JP Jr, McBride E, Snelson R. Comparison of postoperative stump management: Plaster vs. soft dressings. J Bone Joint Surg Am 1971;53:241-249.
8. Golbranson FL, Asbelle C, Strand D. Immediate postsurgical fitting and early ambulation. Clin Orthop Rel Res 1968;56:119-131.
9. Cohen SI, Goldman LD, Salzman EW, Glotzer DJ. The deleterious effect of immediate postoperative prosthesis in the below-knee amputation for ischemic disease. Surgery 1974;76:992-1001.
10. Kane TJ 3rd, Pollak EW. The rigid versus soft postoperative dressing controversy: A controlled study in vascular below-knee amputees. Am Surg 1980;46:244-247.
11. Choudrey SR, Reiber G, Pecoraro JA, et al. Postoperative management of the transtibial amputations in VA hospitals. J Rehabil Res Dev 2001;38:293-298.
12. Wright JG, Swiontkowski MF, Heckman JD. Introducing levels of evidence to the journal. J Bone Joint Surg Am 2003;85-A:1-3.
13. Wu Y, Flanigan DP. Rehabilitation of the lower-extremity amputee with emphasis on a removable rigid below-knee rigid dressing. In: Bergan J, Yao ST, eds. Gangrene and Severe Ischemia of the Lower Extremities. New York: Grune and Stratton; 1978, 435-453.
14. Kinor D, Gaussa E, Sutton E. Alternative to soft dressings: A review. The O & P Edge December 2013.
15. Wu Y, Keagy RD, Krick, Stratigos JS, Betts HB. An innovative removable rigid dressing technique for below-the-knee amputation. J Bone Joint Surg Am 1979;61:724-729.
16. Mueller MJ. Comparison of removable rigid dressings and elastic bandages in prosthetic management of patients with below-knee amputations. Phys Ther 1982;62:1438-1441.
17. Gandhavadi B. Porous removable rigid dressing for complicated below-knee amputation stumps. Arch Phys Med Rehabil 1987;68: 51-53.
18. Richter KJ, Hurvitz EA, Giradot K. Rigid removable dressing in case of poor wound healing. Arch Phys Med Rehabil 1988;69: 128-129.
19. Gendron B, Andrews KL. The use of rigid removable dressings for juvenile amputees: A case report. J Assoc Child Prosthetic-Orthotic Clin 1991;26:4.
20. Hughes S, Solomon N, Wilson S. Use of removable rigid dressing for transtibial amputees rehabilitation: A Greenwich Hospital experience. Aust Physiother 1998;62:1438-1441.
21. Gooday H, Hunter J. Preventing falls and stump injuries in lower limb amputees during inpatient rehabilitation: Completion of the audit cycle. Clin Rehabil 2004;18:379-390.
22. Duetsch A, English RD, Vermeer TC, Murray PS, Condous M. Removable rigid dressings versus soft dressings: A randomized, controlled study with dysvacular, trans-tibial amputees. Prosthet Orthot Int 2005;29:193-200.
23. Emmelot CH, Geertzen JH. Removable rigid dressings versus soft dressings. Prosthet Orthot Int 2006;30:102-103.
24. Tsai P, Geffen S. Use of a polyethylene removable rigid dressing in a transtibial amputee. J Australasian Rehabil Nurs Assoc 2007;10: 22-23.
25. Ladenheim E, Oberti-Smith K, Tablada G. Results of managing transtibial amputations with a prefabricated polyethylene rigid removable dressing. J Prosthet Orthot 2007;19:2-4.
26. Johannesson A, Larsson G, Oberg T, Astroshi I. Comparison of vacuum-formed removable rigid dressing with conventional rigid dressing after transtibial amputation. Acta Orthop 2008;79: 361-369.
27. Taylor L, Cavenett S, Stepien JM, Crotty M. Removable rigid dressings: A retrospective case-note audit to determine the validity of post-amputation application. Prosthet Orthot Int 2008;32: 223-230.
28. Janchai S, Boonhong J, Tiamprasit J. Comparison of removable rigid dressing and elastic bandages in reducing the volume of the residual limb knee amputees below. J Med Assoc Thai 2008;91: 1441-1446.
29. Duwayri Y, Vallabhaneni R, Kirby JP, et al. Early protection and compression of residual limbs may improve and accelerate prosthetic fit: A preliminary study. Ann Vasc Surg 2012;26: 242-249.
30. Hidayati E, Ilyas E, Murdana IN, Tarigan JE, Wedhani RA. Efficacy of removable rigid dressing after transtibial amputation in diabetes mellitus patients. Med J Indones 2013;22:16-21.
31. Sumpio B, Shine SR, Mahler D, Sumpio BE. A comparison of immediate postoperative rigid and soft dressings for below-knee amputations. Ann Vasc Surg 2013;27:774-780.
32. Miller WC, Speechley M, Deathe B. The prevalence and risk factors of falling and fear of falling among lower extremity amputees. Arch Phys Med Rehabil 2001;82:1031-1037.
33. Pauley T, Devlin M, Heslin K. Falls sustained during inpatient rehabilitation after lower limb amputation: Prevalence and predictors. Am J Phys Med Rehabil 2006;85:521-532; quiz, 533-535.
34. Behar TA, Burnham SJ, Johnson G Jr. Major stump trauma following below-knee amputation. Outcome and recommendations for therapy. J Cardiovasc Surg (Torino) 1991;32:753-756.

35. Gonzolez EG, Mathews MM. Femoral fractures in patients with lower extremity amputations. Arch Phys Med Rehabil 1980;61: 276-280.
36. Lewallen RP, Johnson EW. Fractures in amputation stumps: Review of treatment of 16 fractures. Mayo Clin Proc 1981;56: 22-26.
37. Bates DW, Pruess K, Souney P, Platt R. Serious falls in hospitalized patients: Correlates and resource utilization. Am J Med 1995;99: 137-143.
38. Reichmann JP, Rheinstein J. Re: do rigid dressings reduce the time from amputation to prosthetic fitting? A systematic review and meta-analysis. Ann Vasc Surg 2015;29:160-161.

Disclosure

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