Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Treatment of burned children using dermal regeneration template with or without negative pressure

Mauricio José Lopes Pereima [a,*], *Rodrigo Feijó* [b], *Fabiana Oenning da Gama* [c], *Roberto de Oliveira Boccardi* [c]

[a] *Burn Trauma Center — Joana de Gusmão Children Hospital. Departmant of Pediatrics, Federal University of Santa Catarina, Florianópolis, Brazil*

[b] *Burn Trauma Center — Joana de Gusmão Children Hospital, Florianópolis, Brazil*

[c] *Universidade do Sul de Santa Catarina, UNISUL, Florianópolis, Brazil*

ARTICLE INFO

Article history:
Accepted 7 August 2018

Keywords:
Wound healing
Burns
Negative-pressure wound therapy
Child

ABSTRACT

Objective: Evaluate the results obtained using a Dermal Regeneration Template (DRT) associated or not with the Negative Pressure Wound Therapy (NPWT) for skin cover in paediatric patients who were victims of burns.

Method: Retrospective study of a cross-sectional study that evaluated the medical records of children submitted to the application of DRT, associated or not with NPWT, for the treatment of burned children admitted to the Joana de Gusmão Children's Hospital (JGCH) in Florianópolis, in the period from January 2011 to December 2016, totalling 45 patients.

Results: The majority of the patients were pubescent (31.8%) males (56.8%), and the main aetiology of the burn was flammable substances (75%). In the group that used only DRT, the average take of DRT was 85% with an average time of maturity of 17.65 days and the mean take rate of the skin graft was 85.2%. In the group that used DRT plus NPWT, the mean DRT take was 99.8%, with a mean maturation time of 16.68 days and the mean of the skin graft take rate was 89.1%.

Conclusion: NPWT associated with DRT offers a higher rate of success in the treatment of complex wounds caused by burns, promotes increased DRT take rate, reduces DRT maturation time and increases the take rate of the skin graft.

1. Introduction

A burn, by definition, is a tissue injury caused by heat, in any form, by contact with electrical current or chemical substances. Injuries caused by burns are a considerable source of morbidity and mortality, especially in developing countries such as Brazil [1].

Burn injuries are common. They constitute an important public health problem, and generate, in addition to the

Abbreviations: DRT, Dermal Regeneration Template; NPWT, Negative Pressure Wound Therapy; JGCH, Joana de Gusmão Children's Hospital; BBS, Burned Body Surface; BTU, Burn Therapy Unit.

* *Corresponding author at*: Desembargador Pedro Silva 1952, apartamento 502/2– Coqueiros Florianópolis, SC, Brazil, 88080-720.
E-mail address: mauricio.pereima@ufsc.br (M.J.L. Pereima).

https://doi.org/10.1016/j.burns.2018.08.009
0305-4179/

psychological and social damages to victims and their families, large expenditures of resources. Approximately 90% of deaths due to burns involving children occur in developing countries, which do not have prevention and research campaigns aimed at this type of trauma [2,3,4]. In JGCH in Florianópolis, the predominant profile of the hospitalized child victim of burns is a boy under the age of six who was burned at home, especially in the kitchen, by heated liquids [5].

Adequate and early treatment of lesions and the correction of tissue losses are imperative since they predispose mainly to dehydration, temperature variations and infections that are detrimental to the state of health of the affected individual [6,7].

In specialized services for the care of burn victims, the work of a multidisciplinary team is decisive, since the patient, in addition to physical pain, suffers with anxiety, symptoms of post-traumatic illness, low self-esteem and guilt. Family members are also likely to suffer from a similar range of problems. Traumatic aspects involve not only the injury itself, but also the difficult period of treatment and hospitalization that often entails challenging and frightening experiences [8].

In search of the best functional and aesthetic result, and the reduction of complications, the use of dressings to aid healing has been investigated extensively. The dressing aims to favor the healing process, to protect the skin against external aggressors, to absorb and drain exudates, to keep the wound moist and to preserve the integrity of its peripheral region, serving as an essential therapeutic measure in wounds caused by burns [9].

According to the skin thickness burned and the total area burned, different treatments are proposed. Extensive and deep burns in noble areas where better quality skin is demanded may suffer from a scarcity of healthy skin for their reconstruction since, in these cases, the most commonly used treatment is autograft. In such scenarios, the use of skin substitutes, such as DRT, may be a good alternative because, theoretically, such a model of dermal regeneration is available in unlimited quantities it can be applied in practically any affected region, and offers good functional results and aesthetics [3].

DRT combines a collagen template (dermal substitute) with an outer layer of silicone (epidermal substitute), and acts as a synthetic substitute for injured skin. First, the collagen template is incorporated into the wound and, after maturation, the silicone layer is removed and replaced with a thin skin graft (epidermis) and natural dermis. In order to reduce the time of attachment and to achieve better results in the treatment of wounds, the associated use of DRT with NPWT can result in improvement of the take of the template or other graft [10].

However, NPWT was described as a form of adjuvant treatment, aiming to reduce template maturation time and the number of complications, such as hematoma, infection, and DRT detachment. The NPWT consists of the application of a sterile sponge on the lesion bed, and subsequent installation of a plastic adhesive wrap over the sponge forming a closed system in which subatmospheric pressure is applied through a tube coupled to a vacuum pump. The level of pressure usually used is between 80 and 125 mmHg cyclically or continuously. The aspirated fluid is collected in a container with controlled volume [3].

This system, when removing fluid from the wound, apparently reduces edema, improves blood flow, increases neovascularization, and decreases bacterial count when applied to chronic and acute wounds [11].

According to the literature, the DRT take rate without negative pressure varies between 70 and 86% while, with negative pressure, the rate varies from 96 to 100%. The maturation time (DRT placement to the skin graft) with negative pressure varies from 9 to 16 days and, without negative pressure, from 21 to 27 days [5,10]. Total engraftment was observed in 48.15% of the patients submitted to DRT only, however, engraftment without complications or partial loss of the graft was observed in 71.23% of patients when NPWT complemented DRT [5].

In view of the above, this study aims to compare the DRT take rate, the skin graft attachment rate and the maturation time of the template, between DRT dressings alone and DRT dressings associated with NPWT in the treatment of child victims of burns.

2. Method

This is an observational cross-sectional study conducted at the Burn Therapy Unit (BTU) of the JGCH. The medical records of burn victims, regardless of the causal agent, were analyzed from January 2011 to September 2016 who were treated with DRT, with or without subsequent NPWT. Patients of both sexes in the age group 0 to 15 years and 11, burn victims, regardless of the causal agent, the affected body surface and the depth of the lesion were included.

A sample of 40 patients was considered sufficient to compare differences in the mean of at least 20% of the catch rate at a 95% confidence level ($p < 0.05$). In the ratio of the two groups (I and II) of 1:1, a final sample with possible loss of 10% was obtained with 20 patients in each group (40 patients). The parameters used for the calculation of the sample had as reference the study of Jeschke et al. [10], which investigated differences in the take of DRT.

Outcome variables include: DRT Maturation with NPWT and Maturation of DRT without Negative Pressure (in days); DRT Take with NPWT and DRT Take without Negative Pressure; Graft Take with NPWT and Graft Take without Negative Pressure (percentage); and, calculation of the percentage of DRT and skin engraftment. Independent variables were established and include:

- Sex (female or male);
- Age (newborns: 0–29 days, infants: 0 to <2 years, preschoolers: 2 to <6 years, schoolchildren: 6 to <10 years, pubescent: 10 to <12 years and pubescent: 12 to 16 years);
- City of origin;
- Etiology of the lesion (liquid, flammable substance, chemical, or other);
- Burned Body Surface (BBS) rated as <10%, 10–20%, 20–30%, 30–40%, 40–50,> 50%, or indeterminate; and,
- Burn depth (surface, partial thickness, partial surface thickness, deep partial thickness, total thickness, total deep or subdermal thickness).

An instrument of data collection was used addressing the clinical characteristics and treatment elaborated by the

authors. For the information regarding the extent and depth of burns, pre-established protocols were used. In relation to age, they were distributed according to the Marcondes age group criteria [13]. BBS was analyzed through the evaluation proposed by Lund and Browder [14] and distributed in 10% intervals or over 50%. The depth of the burn was classified by the method proposed by Duffy et al. [15].

After data collection, they were processed using Microsoft Office Excel® and exported and analyzed by the SPSS 18.0 program (Statistical Package for the Social Sciences Version). Qualitative variables were described by absolute and relative frequencies, while quantitative variables were described as means and standard deviations. Student's t-test was used in the comparison between two means according to groups of outcome variables. The level of significance was set at $p < 0.05$, with a 95% confidence interval.

This research was submitted to JGCH's ethics and research committee and approved under the opinion number 1,967,595 and CAAE number 65715117.9.0000.5369. The researchers declare no conflicts of interest.

3. Results

In the pre-established period, 44 medical records of patients submitted to treatment with DRT dressings in the BTU of the JGCH were analyzed.

Table 1 shows the sociodemographic characteristics of the burn victims participating in the study.

Table 1 — Sociodemographic characteristics of children who are victims of burns, attended at the BTU of JGCH from 2011 to 2016

Of the children included in the study, 25 (56.8%) were male. The patients' ages ranged from 0 to 15 years with 14 patients presenting in the pubertal group, corresponding to 31.8%. The second most prevalent group was preschoolers with 12 patients (27.2%). As for city of origin, 39 (88.6%) did not come from the great Florianópolis.

Table 2 shows the clinical characteristics of lesions (etiology, BBS), as well as the place of origin of the burn victims

Table 2 — Clinical characteristics of the lesions of burn victims children, attended at the BTU of the JGCH from 2011 to 2016.

Of the analyzed files, 75% of the patients (33 out of 44) suffered burns from flammable substances. Regarding BBS, 11 patients had between 20 and 30% of the body burned, 10 had between 40 and 50%, and 9 burned more than 50% of the body surface. Regarding depth of the burn, 40 patients (90%) suffered from burns of total thickness.

Table 3 presents data on DRT take rate, skin graft take rate, and DRT maturation days in the group that used only DRT and in the group that used DRT+NPWT.

Table 3 — Association of DRT takes, skin graft attachment and maturation days of DRT, associated or not to NPWT, of burn victims attended at the BTU of JGCH from 2011 to 2016.

The template take in the DRT+NPWT group was on average 99.8%±1%. The template take in the DRT group was 85% on average±26.3% with p=0.007. In relation to the graft of the skin graft, in the DRT+NPWT group, the graft attachment was 89.1% with a standard deviation of 32.1 and 25%. The DRT group had a mean of 85.2% standard deviation of 25.9, n=17 and p=0.616. In maturity days of the template, mean DRT +NPWT group was 16.68 days, with a standard deviation of 3.119, and n=25. In the DRT group, the mean number of days was 17.65, with standard deviation of 3.463, n=17 and p value of 0.351.

Table 1 – Sociodemographic characteristics of children who are victims of burns, attended at the BTU of JGCH from 2011 to 2016.

Variables	N	(%)
Gender		
Male	25	56.8
Female	19	43.2
Age range		
Infant	6	13.6
Preschool	12	27.2
School	9	20.4
Pre-Pub	3	6.8
Puber	14	31.8
From		
Florianópolis	1	2.2
São José	4	9
Others	39	88.6

Table 2 – Shows the clinical characteristics of lesions (etiology, BBS), as well as the place of origin of the burn victims.

Variables	N	(%)
Etiology		
Heated liquid	8	18.1
Flammable substance	33	75.0
Others	3	6.8
Burned body surface (%)		
0-10	6	13.6
10–20	2	4.5
20-30	11	25.0
30-40	6	13.6
40-50	10	22.7
>50	9	20.4
Depth of burn		
Partial thickness	3	6.8
Total thickness	40	90.0
Total deep thickness	1	2.2

4. Discussion

The study analyzed 44 medical records of children who were victims of burns, and most were boys (56.8% of the total). Xu et al. [16], in a study published in China, showed that the incidence of burned boys was 1.77 times higher than girls. Studies performed worldwide and in Brazil corroborate this result. On the other hand, data obtained in Asia [12] identify female predominance in burn accidents, especially among

Table 3 – Variables.

(n DRT/n MRD+CPN)	DRT* Average±sd	DRT+NPWT† Average±sd	P value
DRT take (18/25)	85±26,3	99±1.0	0.007
Graft take (17/25)	85.2±25.9	89,1±32.1	0.616
Days of maturaion DRT (17/25)	17.6±3.4	16,6±3.1	0.351

Sd=Standard deviation.
* Dermal regeneration template.
† Dermal regeneration template + negative pressure wound therapy.

adolescents. The greater number of cases in males can be explained by greater domestic exposure, different gender behavior, and cultural factors that provide greater freedom for boys and greater vigilance for girls [17].

In this study, the age group with the most participants was pubertal age at 38.1%, however, the literature shows that the majority of burned children are below four years of age [18]. Children under three to four years of age often remain close to their parents while cooking, and they are restless, exploitative and curious, as well as not yet having motor and intellectual maturity to avoid dangerous situations and are therefore more exposed to burn risks. The pubescent age group is freer to handle flammable materials such as containers with alcohol, for example, and to play with fire, which increases the risk of serious burns.

As the causative agent of burns in children, several studies point to hot liquids as the main cause of burns in infants and preschool children, followed by fire accidents in children from six years of age [19]. According to Machado et al. [20], in a retrospective study of 2961 cases of burns in children under 15 attended to at the Hospital of Andaraí in Rio de Janeiro, between 1997 and 2007, they described a percentage of 49.5 for heated liquids as the principal causal agent. Chemical agents accounted for only 1.04% of the hospitalization rate. Such data differ from the present study, where the main cause of burns were flammable substances.

Such differences may be explained by the fact that flammable substances, such as alcohol, often cause deeper and more extensive burns, which often require the use of DRT (inclusion criterion for patients in this study).

When analyzing the depth of the burn, Duci et al. [25] highlights the fact that 75.7% of the children in their study presented superficial and partial thickness burns. Sobouti et al. [24] corroborates this result, demonstrating a higher prevalence of first and second degree burns. The present study reveals that the vast majority of medical records analyzed showed total thickness burns (90%).

A previous study in this same service analyzed alcohol-burned children between 2001 and 2006, and showed that most patients also presented total thickness lesions, probably due to the severity of the etiological agent [23].

In acute-phase burns, DRT is indicated for the post-excisional treatment of total or partial deep-thickness burns in which there is insufficient autologous tissue for coverage, or when the patient's condition contraindicates the procedure. In the late phase, it is indicated for the treatment of sequelae, such as the release of cicatricial retractions and in hypertrophic scars [26].

In the Pediatric Surgery Service of JGCH, the indications for the use of DRT are: in large burnings that do not have sufficient donor areas and, in small burns, in areas where better quality tissue is found such as the neck, hands, feet, large joints and breasts [27].

In this study, we investigated whether the use of DRT can be undertaken with the use of supplementary technique: use of negative pressure dressing. The goal of the model is to provide a good template for cell and vascular replacement.

In the dermal model, cellular interactions in wounds increase the insertion of fibroblasts and produce a new template of connective tissue. The neoderme biodegrades and is replaced by the normal collagen of the host, without scar tissue. Although the neoderme may be durable, the epidermis should be replaced by a thin skin graft in a second operation, to ensure complete healing of the wound [10].

Among the articles reviewed, the DRT take rate varied from 80 to 100% [28,29]. Groos et al. [30], in a study with 20 DRT implants in children, found lossof more than 50% of implanted surface area in 35% of the patients, showing results lower than those found. Jeshke et al. [10] compared two groups: one using DRT only and one using DRT+negative pressure and fibrin glue. Such a study demonstrated a DRT take rate of 78±8% in the conventional group, compared to 98±2% in the group that used negative pressure and fibrin glue over the DRT. McEwan et al. [31], as well as Park et al. [32], used DRT in association with NPWT and reported an average 98% conversion of the template into neoderm. In the analysis of the JGCH research line, performed by Goulart et al. [33], the total take of DRT occurred in 15 (83.33%) of the 18 patients. According to Wunderlich et al. [5], the total number of patients submitted to NPWT was 83.33% of the patients, which was greater than that of the DRT group, which obtained total take in 70.91% of the patients. In cases where there was partial implant loss, the mean partial catch rate was 80% in the DRT+NPWT group versus 63.21% in the group receiving only DRT.

In the present study, the take of the template in the DRT +NPWT group was on average 99.8%, and the take of the template in the DRT group without negative pressure was 85% on average. This fact suggests a constant and progressive learning curve of the JGCH Burn Service. It is important to note that the criteria used for the maturation of DRW with NPWT are the same as those used for children who only used DRT, that is the matrix color and the detachment of the silicone layer, clinical parameters indicating its complete neovascularization standards. No biopsies were performed.

Regarding the maturation days of DRT, in studies previously performed in this same service by Maes et al. [27], the skin graft was performed about 21 days following the DRT implant, after maturation. Already Wunderlich et al. [5], observed a decrease in the time necessary for maturation of the template in the group that used NPWT+DRT. The observed time was 15.88 days in this group, while it was 21.56 days in the group that used only DRT. Clinical studies, including the Guidelines cited by Bovill et al. [34], showed an average rate of 7 to 25 days for the vascularization of the DRT [35]. Jeshke et al. [10] demonstrated an average 24±3 day interval from the DRT implant to the skin graft in the group in which only DRT was used. In the DRT group plus fibrin glue and NPWT, the interval was 10±1 days on average.

In comparison, the present study showed that, in the group where only DRT was used, the maturation time was on average 17.65 days, versus 16.68 days in the DRT plus NPWT group. Although not statistically significant, these results show a tendency to decrease maturation time of DRT associated with NPWTwith significantly better results than the majority of the data reported in the literature.

The lower number of days for maturation of DRT found in this study and in other studies that associated it with negative pressure seems to be related to the ability of this dressing to reduce edema and the risk of infection, and to increase the blood supply in the lesion bed, according to literature data [35]. The casuistry of this work evidences the tendency to the earlier maturation of DRT associated to NPWT.

Regarding the rate of engraftment of the skin graft, in a previous study conducted in this same hospital, total engraftment, without any type of complication, was observed in 48.15% of patients submitted to DRT only. In comparison, in patients submitted to NPWT supplementation, the total engraftment of the skin graft, without any type of complication, was observed in 71.23%. Another study, performed in the JGCH by Goulart et al. [33], using DRT+NPWT, showed a mean of 93.62% autograft, where 13 (72.23%) patients had total take, three had partial take with a need for new grafting, and two presented partial engraftment.

In the present study, the group treated with DRT only had a mean engraftment rate of 85.2%. In the group treated with DRT plus NPWT there was improvement of the result: the average rate of grafting of the skin graft was 89.1%.

Although in both groups grafting was performed only when the template was considered mature, with clinical parameters indicating its complete neovascularization, the superior result for the DRT+NPWT group, suggests that the neoderm formed with the use of the NPWT may be related to a better vascular neoformation stimulated by the negative environment. Such information, however, still lacks scientific evidence. Finally, it is important to mention that although there are no previous comparative studies of the use of DRT with and without NPWT between adults and children, pediatric patients are constantly growing and developing, with a more intense cellular activity and do not present with typical degenerative diseases of adults, which could justify its better results in the take of matrices in relation to adults.

5. Conclusions

NPWT was shown to be beneficial to adjunctive treatment with DRT by reducing the maturation time of the template to 16.68 days on average, increasing the average take rate to 99.8%, and increasing the take rate of the skin graft to 89.1% on average.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

[1] Bartosch I, Bartosch C, Egipto P, Silva Á. Factors associated with mortality and length of stay in the Oporto burn unit (2006–2009). Burns 2013;39(3):477–82.
[2] Peck M. Epidemiology of burns throughout the world: part I: distribution and risk factors. Burns 2011;37(7):1087–100.
[3] Dumville J, Munson C. Negative pressure wound therapy for partial-thickness burns. Cochrane Database of Syst Rev 2012.
[4] Cruz B, Cordovil P, Batista K. Perfil epidemiológico de pacientes que sofreram queimaduras no Brasil: revisão de literatura. Rev Bras Queimaduras 2012;11(4):246–50.
[5] Wunderlich B, Marcolla B, Souza J, Araujo E, Feijó R, Pereima M, et al. Curativo com pressão negativa e Matriz de Regeneração Dérmica: uma nova opção de tratamento para feridas extensas. Rev Bras Queimaduras 2011;10(3):78–84.
[6] Rowan M, Cancio L, Elster E, Burmeister D, Rose L, Natesan S, et al. Burn wound healing and treatment: review and advancements. J Child Psychol Psychiatr 201519(1).
[7] Graf A, Schiestl C, Landolt M. Posttraumatic stress and behavior problems in tnfants and toddlers with Burns. J Pediatr Psychol 2011;36(8):923–31.
[8] De Young A, Kenardy J, Cobham V, Kimble R. Prevalence, comorbidity and course of trauma reactions in young burn-injured children. J Child Psychol Psychiatr 2011;53(1):56–63.
[9] Meuli M, Trop M, Neuhaus K, Schiestl C. Management of burn wounds. Eur J Pediatr Surg 2013;23(05):341–8.
[10] Jeschke M, Rose C, Angele P, Fuchtmeier B, Nerlich M, Bolder U. Development of new reconstructive techniques: use of integra in combination with fibrin glue and negative-pressure therapy for reconstruction of acute and chronic wounds. Plast Reconstr Surg 2004;113(2):525–30.
[11] Molnar J, DeFranzo A, Hadaegh A, Morykwas M, Shen P, Argenta L. Acceleration of integra incorporation in complex tissue defects with subatmospheric pressure. Plast Reconstr Surg 2004;113(5):1339–46.
[12] Peden M, Oyegbite K, Ozanne-Smith J, Hyder A, Branche C, Rahman A, et al. Burn. World report on child injury prevention. Geneve: World Health Organization; 2008. p. 79–94.
[13] Marcondes E. Pediatria básica. 9th ed. São Paulo:Editora Sarvier; 2002.
[14] Lund C, Browder N. The estimation of areas of burns. Surg Gynecol Obstet 1944;79:352–8.
[15] Duffy BJ, McLaughlin PM, Eichelberger MR. Assessment, triage, and early management of burns in children. Clin Pediatr Emerg Med 2006;7:82–93.
[16] Xu J, Qiu J, Zhou J, Zhang L, Yuan D, Dai W, et al. Pediatric burns in military hospitals of China from 2001 to 2007: a retrospective study. Burns 2014;40(8):1780–8.
[17] Alaghehbandan R, Sikdar K, Gladney N, MacDonald D, Collins K. Epidemiology of severe burn among children in Newfoundland and Labrador Canada. Burns 2012;38(1):136–40.
[18] Spinks A, Wasiak J, Cleland H, Beben N, Macpherson A. Ten-year epidemiological study of pediatric Burns in Canada. J Burn Care Res 2008;29(3):482–8.
[19] Olawoye O, Iyun A, Ademola S, Michael A, Oluwatosin O. Demographic characteristics and prognostic indicators of childhood burn in a developing country. Burns 2014;40 (8):1794–8.
[20] Machado THS, Lobo JA, Pimentel PCM, Serra MCVF. Estudo epidemiológico das crianças queimadas de 0-15 anos atendidas no Hospital Geral do Andaraí: durante o período de 1997 a 2007. Rev Bras Queimaduras 2009;8(1):3–9.
[23] Pereima MJ, Mignoni ISP, Bernz LM, Schweitzer CM, Souza JA, Araújo EJ, et al. Análise da incidência e da gravidade de queimaduras por álcool em crianças no período de 2001 a 2006: impacto da Resolução 46. Rev Bras Queimaduras 2009;8(2):51–9.

[24] Sobouti B, Fallah S, Ghavami Y, Moradi M. Serum immunoglobulin levels in pediatric burn patients. Burns 2013;39(3):473–6.
[25] Duci S, Arifi H, Selmani M, Gashi S. Pediatric burns in University Clinical Center of Kosovo from 2005–2010. Burns 2014;40(8):1789–93.
[26] Bloemen MC, van der Veer WM, Ulrich MM, van Zuijlen PP, Niessen FB, Middelkoop E. Prevention and curative management of hypertrophic scar formation. Burns 2009;35(4):463–75.
[27] Maes NB, Manara LM, Feijo R, Araujo EJ, Souza JA, Pereima MJ. Uso de matriz de regeneração dérmica em pacientes vítimas de queimaduras em hospital infantil de referência de Santa Catarina: nove anos de experiência. Rev Bras Queimaduras 2012;11(1):6–14.
[28] Muangman P, Engrav LH, Heimbach DM, Harunari N, Honari S, Gibran NS, et al. Complex wound management utilizing an artificial dermal template. Ann Plast Surg 2006;57(2):199–202.
[29] Sheridan R, Hegarty M, Tompkins RG, Burke JF. Artificial skin in massive burns: results to ten years. Eur J Plast Surg 1994;17(2):91–3.
[30] Groos N, Guillot M, Zilliox R, Braye F. Use of an artificial dermis (Integra) for the reconstruction of extensive burn scars in children. About 22 grafts. Eur J Pediatr Surg 2005;15(3):187–92.
[31] McEwan W, Brown T, Mills S, Muller M. Suction dressings to secure a dermal substitute. Burns 2003;30:259–61.
[32] Park CA, Defranzo AJ, Marks MW, Molnar JA. Outpatient reconstruction using integra and subatmospheric pressure. Ann Plast Surg 2009;62(2):164–9.
[33] Goulart BC, Valentim L, Pereima MJ, Souza JA, Araújo EJ, Capella MR, et al. Análise do tempo de maturação dos implantes de matriz de regeneração dérmica utilizando curativos sob pressão negativa. Rev Bras Queimaduras 2010;9(4):124–9.
[34] Bovill E, Banwell PE, Teot L, Eriksson E, Song C, Mahoney J, et al. Topical negative pressure wound therapy: a review of its role and guidelines for its use in the management of acute wounds. Int Wound J 2008;5(4):511–29.
[35] Gregor S, Maegele M, Sauerland S, Krahn JF, Peinemann F, Lange S. Negative pressure wound therapy: a vacuum of evidence? Arch Surg 2008;143(2):189–96.