ORIGINAL ARTICLE

Muscle-sparing latissimus dorsi flap for inferior limb's defects reconstruction in children

Colgajo dorsal ancho preservador de músculo para la reconstrucción de defectos en la extremidad inferior en niños

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Abstract

Objective: *To evaluate the aesthetic and functional outcomes as well as the degree of postoperative satisfaction of the lower limb's defects reconstruction with a muscle-sparing latissimus dorsi flap in children in order to propose this kind of reconstruction as a secure alternative.* **Method:** *In this study were included patients under 18 years with lower limb's defects treated over a period of 3 years A muscle-sparing latissimus dorsi flaps was performed in all patients. After three months the flap was performed it was evaluated the donor's area muscular strength, recipient area function and aesthetic appearance.* **Results:** *They were made 13 muscle-sparing latissimus dorsi flaps. In most cases, the donor and recipient area have satisfactory aesthetic appearance, most of the patients had a normal muscular strength (M5) in donors' area and were able to walk.* **Conclusions:** *The reconstruction using a muscle-sparing latissimus dorsi flap has a very high level of satisfaction, excellent symmetry, and preservation of donor area muscle function, It is an ideal technique for major tissue defects of lower limb in children.*

Keywords: *Flap. Reconstruction. Lower limb. Children.*

Resumen

Objetivo: *Evaluar los resultados estéticos y funcionales, así como el grado de satisfacción, posteriores a la reconstrucción de defectos de la extremidad inferior en niños con colgajo de dorsal ancho preservador del músculo como una alternativa para estos casos.* **Método:** *Se incluyeron pacientes menores de 18 años con defectos en la extremidad inferior tratados en un periodo de 3 años. Se realizó colgajo dorsal ancho preservador de músculo en todos los pacientes. Se valoraron la apariencia estética, la fuerza muscular del área donadora y la función en el área receptora a los 3 meses de realizado el colgajo.* **Resultados:** *Se realizaron 13 colgajos de dorsal ancho preservadores de músculo. La apariencia estética de las áreas donadora y receptora fue satisfactoria en la mayoría de los casos. La mayoría de los pacientes presentaron una fuerza muscular normal (M5) en el sitio donador y pudieron deambular.* **Conclusiones:** *El colgajo de dorsal ancho preservador de músculo tiene un grado de satisfacción muy elevado, excelente simetría y preservación de la función muscular del sitio donador. Es una técnica ideal en defectos tisulares importantes de la extremidad inferior en la población pediátrica.*

Palabras clave: *Colgajo. Reconstrucción. Extremidad inferior. Niños.*

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Introduction

Lower limb severe trauma in the pediatric population is less common than in adults. The most common causes are high-energy trauma to the ankle or foot resulting from motor vehicle accidents, electrical machinery, gunshot wounds, and falls[1].

The surgical techniques that are commonly employed on this site usually require microsurgery; however, reconstruction with free flaps in the pediatric population requires a series of special considerations. Among these, we can mention the potential effect on growth and development, the psychological problems that entail performing a major surgery in pediatric patients, disability at early ages, lack of cooperation and smaller caliber of vessels[1-3], which is why it represents a major therapeutic challenge.

However, microsurgery in this population has high success rates[4-9] due to the lack of development of the muscle layer in the vessels, which decreases the presence of spasms and atherosclerosis does not develop, which explains the low incidence of vascular problems[10].

The flaps most often described for lower limb reconstruction are those of anterior serratus, rectus abdominis and latissimus dorsi[1,11,12]. The latissimus dorsi flap is one of the most widely used in microsurgery[13], although it has the disadvantage of producing a functional deficit in the upper extremity, with loss of extension, adduction and internal rotation of the arm[14-16], in addition to the esthetic alterations it causes at the donor site, such as the scar and thoracic silhouette shape change[17,18].

To avoid these complications, the use of a muscle-sparing latissimus dorsi flap has been described, which unlike traditional latissimus dorsi flap, only includes a portion of this muscle[19-21]. Flaps have been reported in which the thoracodorsal artery internal or medial branch has been used for taking a muscle segment, which have shown excellent functional results[22,23], with a thinner and easily managed flap being obtained[24]. It is possible to perform a muscle-sparing flap both with the transverse and descending branches of the thoracodorsal artery, and it has been shown that there are no significant differences in musculocutaneous perfusion of both branches[25]. This type of flaps have been shown to have good esthetic results in terms of symmetry of the thoracic silhouette and donor site scar, with no muscle strength deficit occurring[23]. There are reports of traditional latissimus dorsi free flaps, without muscle preservation, for lower extremity reconstruction in children as a good option for coverage, but they do not evaluate the functional deficit of the donor site and neither the esthetic results achieved with this type of flaps[1-3,6,26].

There are few studies on the use of muscle-sparing latissimus-dorsi flaps in pediatric patients[22,27,28], and those that have been carried out do not include only patients for lower limb reconstruction. In addition, esthetic and functional analysis after the use of this flap is poor, which is why we decided to carry out this study with the purpose to evaluate the esthetic and functional result of the muscle-sparing latissimus dorsi flap (at recipient and donor sites) used in the reconstruction of lower limb defects in children.

Method

This study was conducted at Hospital Universitario Dr. José Eleuterio González, in Monterrey, Nuevo León, Mexico. It is an observational, prospective, descriptive, longitudinal study, which was carried out during the period from March 1, 2015 to February 28, 2018.

Inclusion criteria consisted of patients younger 18 years who had lower extremity defects that were treated within the first 15 days after the injury and that required free flap coverage. In all patients, vascular and bone injuries had already been resolved at the time the flap procedure was carried out. Patients with altered state of consciousness or poor quality receptor vessels were excluded. The elimination criterion was that, for whatever reason, protocol-specified follow-up was not possible.

Demographic data such as gender and age, etiology of the lesion, days elapsed from hospital admission to flap implantation, days of hospital stay, and follow-up were evaluated for all patients.

Surgical technique

The muscle-sparing latissimus dorsi free-flap technique was used with the thoracodorsal artery descending branch being employed as pedicle and anastomosis being performed with microsurgery, using one or two perforating arteries. Prior to the procedure, marking is carried out by locating a point 8 cm below the posterior axillary fold and 2 cm behind latissimus dorsi lateral border, and by means of portable Doppler, the perforating arteries that correspond to the path of

the thoracodorsal artery descending branch are identified and marked. Subsequently, the flap is designed with the axillary midline as its axis.

In the operating room, the recipient area was prepared by debridement, which provided us the actual dimensions of the defect to be covered, and the recipient vessels were identified. The patient was positioned in lateral decubitus and the side where the flap was to be obtained was left exposed.

Incision and dissection were performed on the lateral border of the marked island, including the latissimus dorsi lateral border together with previously-marked perforating arteries. The latissimus dorsi muscle resection limits that were included with the island were 3 cm distal to the perforating artery with the highest flow detected by Doppler and 3 cm medial to the lateral border of the muscle. Next, the proximal vessels were dissected until reaching the subscapular vessels, with integrity of the thoracodorsal nerve being preserved to later perform the end-to-end anastomosis with the recipient vessel with 9-0 Ethilon® (Figs. 1 and 2).

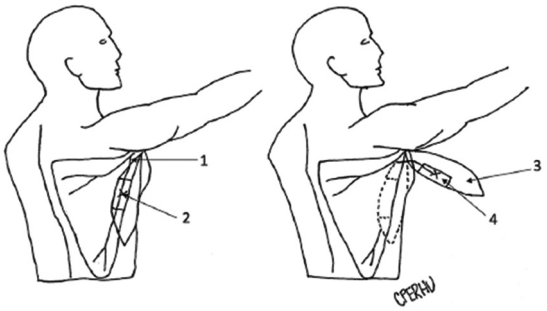

Figure 1. *Design and lifting of the muscle-sparing latissimus dorsi flap. 1: thoracodorsal artery descending branch; 2: perforating artery; 3: skin island; 4: latissimus dorsi muscular portion included in the flap.*

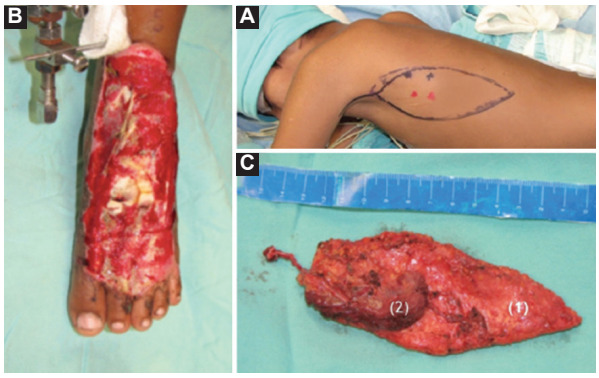

Figure 2. *Marking, area of exposed tissue and flap in an 8-year-old male patient with an injury to the left foot dorsum resulting from a car accident.* **A:** *perforating arteries identification and marking by portable Doppler in the path of the thoracodorsal artery descending branch.* **B:** *exposed-tissue area on left foot dorsum, with extensor tendons loss.* **C:** *flap with skin island (1) and a portion of latissimus dorsi muscle (2).*

Follow-up

Patients were evaluated weekly for the first month and then monthly for up to 9 months. The esthetic and functional evaluation was carried out by applying the scales three months after the surgical procedure in all patients.

Esthetic evaluation

On the visit of the third month after the surgical procedure, esthetic appearance of the scars and body symmetry of both the donor site and recipient site were assessed, in addition to arm mobility, in relation to latissimus dorsi remnant.

Two evaluations were carried out: one by the parent or legal guardian and one by two separate surgeons, one whom was part of the research team and other who was blinded to the research, which is why three evaluations were obtained from each patient (39 evaluations in total). Donor and recipient sites characteristics, esthetic appearance of the scar on the back and on the lower extremity were evaluated using a 4-point Likert-type scale[29], designed as an evaluation protocol for this study (0 = almost imperceptible scar, 1 = slightly evident scar, 2 = moderately evident scar, 3 = highly evident scar), and body symmetry of the back and lower extremity (0 = excellent, 1 = good, 2 = poor, 3 = very poor).

Functional evaluation

Functional evaluation was carried out at third month of the postoperative period, in two parts: one was carried out by the parent or legal guardian, and another by two separate surgeons, one who was member of the research team and another who was blind to the research, and, therefore, three evaluations were obtained from each patient (39 evaluations in total).

The subjective assessment by the parent or legal guardian was related to arm mobility, and was asked to be described on a Likert-type scale[29] designed as an evaluation protocol for this study (0 = performs all movements without problem, 1 = performs movements

Table 1. Demographic data and complications

Patient	Age (years)	Gender	Cause of injury	Days to flap procedure	Complications
1	17	M	Trauma	6	No
2	14	M	Burn	3	No
3	15	F	Trauma	3	No
4	10	M	Cancer resection	1	No
5	4	M	Trauma	4	No
6	15	F	Trauma	2	No
7	16	M	Trauma	15	Partial skin necrosis
8	9	F	Trauma	2	No
9	14	M	Trauma	7	No
10	12	F	Cancer resection	1	Flap partial loss
11	10	M	Trauma	3	No
12	12	F	Trauma	4	No
13	10	M	Cancer resection	1	Donor site 4-cm dehiscence

F: females; M: males.

with mild difficulty, 2 = performs movements with moderate to severe difficulty, 3 = cannot perform the movements). The evaluation by surgeons included the ability to ambulate (ambulates unassisted, ambulates with assistance, or does not ambulate) and ability to carry out shoulder extension, adduction, and rotation. The latter evaluation was based on the Medical Research Council muscle strength scale[30] (M0 = no contraction, M1 = weak contraction that does not move the joint, M2 = active movement, not against gravity, M3 = active movement against the force of gravity, M4 = active movement against the force of gravity and examiner resistance, M5 = normal strength).

This study was approved by the ethics and research committee of Hospital Universitario Dr. José Eleuterio González.

Results

Within the study period, 14 patients were included, among whom one evolved with flap necrosis (7.1%) and was thus excluded, with 13 patients being left for the analysis of results, among whom 8 were males and 5 females, with an average age of 12.1 years and a range of 4 to 17 years.

All 13 flaps were of the muscle-sparing latissimus dorsi type, and average follow-up was 6.3 months, with a range of 3.1 to 9.5 months. The most common injury etiology was trauma in 9 patients (69%); in 3 patients (23%), it was secondary to an oncological resection, and in 1 patient (8%), it was caused by burns. The time elapsed from the time of injury to the surgical procedure was on average 4 days, with a range of 1 to 15 days. Postoperative complications occurred in 3 patients (23%) (Table 1).

Regarding evaluation of the scar (esthetic appearance on the back), among 39 evaluations, 41% of evaluators reported an almost imperceptible scar; 38%, slightly evident; 8%, moderately evident; and 13%, highly evident (Table 2). As for esthetic appearance of the scar in the lower extremity, the evaluators also reported that the scar was almost imperceptible in 41%, slightly evident in 26%, moderately evident in 15% and highly evident in 18% (Table 3). In the body symmetry esthetic appearance evaluation of the back, of the 39 evaluations, 67% were classified as excellent, 15% as good, 10% as poor and 8% as very poor (Table 2). In the case of lower limb esthetic appearance and symmetry, 79% were classified as excellent symmetry and 21% were classified as good (Table 3).

On arm mobility subjective assessment by the parent or legal guardian, they considered that 54% perform all movements without problem and 46% with slight difficulty.

Table 2. Donor site (back) esthetic appearance evaluation

Patient	Scar			Symmetry		
	Parent	Surgeon 1	Surgeon 2	Parent	Surgeon 1	Surgeon 2
1	3	3	2	1	1	3
2	1	1	1	0	0	2
3	0	0	0	0	0	1
4	1	1	0	0	0	0
5	1	2	1	0	0	2
6	0	0	0	0	0	0
7	3	3	1	1	1	3
8	0	0	0	0	0	1
9	1	1	1	0	0	2
10	1	0	0	0	0	0
11	0	0	0	0	0	0
12	1	1	0	0	0	2
13	3	2	1	0	0	3

Results of all 39 evaluations of esthetic appearance of the back based on a Likert-type scale. Scar: 0 = almost imperceptible (16 [41%]), 1 = slightly evident (15 [38%]), 2 = moderately evident (3 [8%]), 3 = highly evident (5 [13%]). Symmetry: 0 = excellent (26 [67%]), 1 = good (6 [15%]), 2 = poor (4 [10%]), 3 = very poor (3 [8%]).

Table 3. Receptor site (lower extremity) esthetic appearance evaluation

Patient	Scar			Symmetry		
	Parent	Surgeon 1	Surgeon 2	Parent	Surgeon 1	Surgeon 2
1	3	3	3	1	1	1
2	2	2	2	0	0	0
3	0	0	0	0	0	0
4	1	1	1	0	0	1
5	1	1	0	0	0	0
6	0	0	0	0	0	0
7	3	3	1	0	0	0
8	0	0	0	0	0	0
9	1	2	0	0	0	0
10	0	0	0	0	0	0
11	0	1	0	0	0	1
12	2	2	1	0	0	0
13	3	3	1	1	1	1

Results of all 39 evaluations of lower extremity esthetic appearance based on a Likert-type scale. Scar: 0 = almost imperceptible (16 [41%], 1 = slightly evident (10 [26%], 2 = moderately evident (6 [15%]), 3 = highly evident (7 [18%]). Symmetry: 0 = excellent (31 [79%]), 1 = good (8 [21%]), 2 = poor (0 [0%]), 3 = very poor (0 [0%]).

As for ambulation, 9 patients (69%) were able to ambulate with no problem, 3 patients (23%) did it without support and 1 patient (8%) was unable to ambulate due to a tendon rupture that had not been diagnosed.

On the 39 evaluations of shoulder muscle strength, 62% in extension, 77% in adduction and 62% in internal rotation were classified as M5 (Table 4).

As for flap procurement, in 8 cases was a perforating artery included, and in 5 cases, two perforating arteries were included. In 10 of all 13 flaps, the perforating arteries were found within a diameter of 3 cm on the referred marking. The size of the skin island that was used ranged from 6 cm wide and up to 25 cm long. Primary donor site closure was performed in all patients. Flap survival was obtained in 13 of the 14 cases (92.9%). Three complications (23%) occurred in the postoperative period of the 13 patients: one partial loss of the flap that was managed with dressings and did epithelialize; in another patient, the flap suffered only a partial loss of skin and was resolved with a partial thickness skin graft; and a 4-cm wound dehiscence at the donor site in another case that was managed with tertiary closure.

Contour and esthetic appearance were satisfactory in most patients, and they were able to use footwear with no problems. The posterior axillary fold was preserved in all cases. No infections, seromas or hematomas occurred.

Discussion

With the introduction of the perforating artery-based myocutaneous free flap, the concept of muscle as an element that provides vascularity is no longer necessary. The use of this type of flap avoids unnecessary thickness and preserves muscle function.

We evaluated esthetics at recipient and donor sites, a parameter regarded as important for patient prognosis. In addition, in patients with foot injuries, we evaluated the ability to use footwear, an aspect not evaluated in previous publications and basic for social integration.

Buntic et al.[22] reported the use of muscle-sparing latissimus dorsi flap in 13 patients, two of them pediatric. The flaps included the thoracodorsal artery internal or medial branch, taking the upper part, and reported good thoracic symmetry and good functioning of the latissimus dorsi. They used persistent pain, donor site weakness and early fatigue to movements related to the use

Table 4. Upper extremity donor site (residual latissimus dorsi) functional evaluation

Patient	Surgeon 1			Surgeon 2		
	Shoulder extension	Shoulder adduction	Shoulder internal rotation	Shoulder extension	Shoulder adduction	Shoulder internal rotation
1	M5	M5	M5	M5	M5	M5
2	M5	M5	M5	M5	M5	M5
3	M4	M4	M4	M4	M4	M4
4	M4	M4	M3	M4	M4	M3
5	M5	M5	M5	M5	M5	M5
6	M5	M5	M5	M5	M5	M5
7	M5	M5	M5	M5	M5	M5
8	M5	M5	M5	M5	M5	M5
9	M5	M5	M5	M5	M5	M5
10	M4	M5	M4	M4	M5	M4
11	M4	M4	M4	M4	M4	M4
12	M5	M5	M5	M5	M5	M5
13	M4	M5	M4	M4	M5	M4
M0	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
M1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
M2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
M3	0 (0%)	0 (0%)	1 (7%)	0 (0%)	0 (0%)	1 (7%)
M4	5(38%)	3 (23%)	4 (31%)	5(38%)	3 (23%)	4 (31%)
M5	8 (62%)	10 (77%)	8 (62%)	8 (62%)	10 (77%)	8 (62%)
Total	13 (100%)	13 (100%)	13 (100%)	13 (100%)	13 (100%)	13 (100%)

Upper extremity muscle strength evaluation results according to the Medical Research Council muscle strength scale. M0 = no contraction, M1 = weak contraction that does not move the joint, M2 = active movement but not against gravity, M3 = active movement against the force of gravity, M4 = active movement against the force of gravity and examiner resistance, M5 = normal strength.

of the latissimus dorsi as parameters to assess muscle function. In our study we did not assess the thoracic region pain parameter, because we considered that it is a factor at the donor site and is not correlated with the purposes of our study.

Schwabegger et al.[27] carried out a subjective and objective evaluation only of the donor site, with excellent results in most cases, with defects being identified in the contour. Motor function was only evaluated with the maneuver of shoulder joint extension with the extremity extended against the examiner's hand. This publication included adult and pediatric patients, and reconstruction of various defects, but not of the lower extremity.

Our motor evaluation considered the three movements of the shoulder joint in which latissimus dorsi muscle participates (extension, adduction and internal rotation), and the fact of including two surgeons gives us more objective information. Shoulder mobility evaluation by the parent or legal guardian was highly important, since they assess their daily activities, which is something that cannot be seen on follow-up visits.

Anticoagulation regimen for children has not been established. Canales et al.[7] used low molecular weight dextran for 5 days and aspirin for 4 weeks. Like Van Beek et al.[31] and Chiang et al.[3], we used dextran 40 for 4 days and 100-mg aspirin for 15 days.

In the present study of 14 cases, there was loss of a flap due to venous thrombosis and, there were two patients with partial loss. In the series by Canales et al.[7], 13 flaps were lost in 106 patients. Seong et al.[32] report about four pediatric patients with defect reconstruction with a thoracodorsal artery perforator flap without flap losses.

Figure 3. *Follow-up and postoperative assessment of an 8-year-old male patient with an area of exposed tissue at left foot dorsum resulting from a car accident, which underwent muscle-sparing latissimus dorsi flap. Adequate esthetic appearance of the scar on the back and lower extremity, symmetry of the back and preserved muscle strength.*

In a study on microsurgical reconstruction with free flaps in children, in which five latissimus dorsi flaps were used, with significant muscle sacrifice, there was a morbidity of 35.3%[33].

Both the muscle-sparing latissimus dorsi flap and the thoracodorsal artery perforator flap have better functional and esthetic results at the donor site than the latissimus dorsi free flap. However, the thoracodorsal artery perforator flap requires a more meticulous microsurgical dissection of the perforating arteries, especially in vessels as small as those of children, it requires more surgical time and has a higher risk of flap loss than the muscle-sparing latissimus dorsi flap[23,25].

The latissimus dorsi contralateral to the site of the injured lower extremity was preferred as donor in order to be able to work in two teams. The thickness of the skin down to the deep fascia on upper and lateral back portions is usually comparable to that on lower extremity distal part, as demonstrated by the symmetry obtained at the receptor site. The resulting scar at the donor area was of good characteristics and, in addition, it is covered by clothing.

The patients included in our study represent the largest number of pediatric patients with lower extremity defects treated with a muscle-sparing latissimus dorsi flap. The results of our study allow us to propose another option for the reconstruction of lower extremity important tissue defects in children.

The procurement of the muscle-preserving latissimus dorsi flap is a valuable technique and achieves a double objective: to preserve muscle function and posterior axillary fold esthetic appearance. This flap also provides a long pedicle with a thin skin island to reconstruct lower extremity defects in children, which results in coverage of the defect with a flap that resembles soft tissues at this level (Fig. 3).

Conclusion

Muscle-sparing latissimus dorsi flap has a very high degree of satisfaction, with excellent symmetry and function preservation, which is why we consider it to be an ideal technique for the reconstruction of lower extremity defects in children, and we propose for it be taken into consideration as a reconstructive option for important lower extremity tissue defects in the pediatric population.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained informed consent from the patients and/or subjects referred to in the article. This document is in the possession of the corresponding author.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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