



Orthoplasty with flaps in fractures with loss of coverage. A single-center observational study.

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Abstract

Introduction: Repairing musculoskeletal injuries in the extremities is challenging for orthopedic surgery. These lesions must be flexible and vascularized, and the devices must cover compromised anatomical structures. This study demonstrated the effectiveness of combining plastic surgery with orthopedic techniques (orthoplasty) for resolving skin defects in the extremities.

Methods: The present study is descriptive and retrospective in patients treated for skin loss in the extremities at the Traumatology Service of the Alcívar Hospital, 2020-2022.

Results: There were 33 patients—28 men and five women—with an average age of 32. Thirty-three flaps were made: 10 cutaneous, 11 fasciocutaneous, eight muscular, and four vascular. A high degree of postsurgical satisfaction was obtained according to the Likert scale.

Conclusions: The resolution of skin defects improves the skeletal fixation of fractures through the return of the form and function of the extremities.

Keywords:

MeSH: Surgical Flaps, Wounds and Injuries, Extremities, Orthopedics, Traumatology.

Abbreviations

FDMA: First dorsal metacarpal artery

Supplementary information

No supplementary materials are declared.

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Author contributions

Hugo Ernesto Villarroel Rovere: Conceptualization, data curation, formal analysis, acquisition of funds, research, writing - original draft.

Carlos Alberto Jaramillo Becerra: conceptualization, data curation, formal analysis. Manuel Betancourt Castillo: Conceptualization, data curation, formal analysis, acquisition of funds.

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Introduction

Orthoplasty was described in 1993 by L. Scott Levin, MD, and FACS and focused on immediate multidisciplinary collaboration among orthopedic surgeons to manage traumatic lower extremity injuries [1]. The benefits of the orthoplastic approach include decreased time to definitive skeletal stabilization or soft tissue coverage, reduced risk of wound infections or osteomyelitis, length of hospital stay, postoperative complications, need for revision procedures, and improved functional outcomes [2, 3].

The use of flaps dates back to 600 BC when the first frontal flaps for nasal reconstruction were applied; without understanding why the flaps survived, the evolution of the flaps was slow based on experience and gradual knowledge of anatomy. Only in the World War did Harold Gillies et al. develop pedicled, tubular, and delayed skin flaps for different musculocutaneous defects. In 1970, musculocutaneous flaps were described; Mathes and Nahai 1981 classified musculocutaneous flaps based on their vascular anatomy, and perforator-free flaps were described in 1990 [4].

Historically, the discipline of plastic and orthopedic surgery developed techniques for the treatment of soft tissue and bone injuries, dating back to Godina's publication in 1986, which demonstrated the advantages of early coverage of extremity trauma; earlier, the orthoplastic approach was associated with a greater likelihood of limb salvage [5, 6].

A flap is a segment of vascularized tissue mobilized from a donor site to an adjacent or distant area. It differs from a graft in that it obtains blood flow from the revascularization of the recipient site; however, the flap can be irrigated [7, 8].

Resection and opening of wounds in the extremities require reconstruction for several reasons; any exposed bone not covered by vascularized soft tissue is at greater risk of osteomyelitis, necrosis in the worst case, or sepsis [9, 10]. Osteomyelitis is one of the significant causes of amputation after leg trauma, and open wounds can cause functional limitations, chronic pain, inability to move freely, significant medical expenses, and unemployment. We must also consider that exposed tendons begin necrotizing, and exposed vessels are more likely to rupture [11].

The flap selection criteria for limb reconstruction were based on the wound surface area, type of tissue deficiency, pedicle length, volume of deficient tissue, and donor site morbidity [12]. Surgical management aims to ensure local perfusion of the affected tissues, surgical cleaning, sequential and early debridement, and infection prevention, followed by adequate coverage with vitalized tissue to cover critically compromised anatomical structures while preserving the exposed

tissue and its functionality [13–16]. The selection of the coverage technique will depend on the location of the defect and its extent [17].

Traumatic injuries with loss of skin coverage at the distal end of extremities constitute an excellent challenge for orthopedic traumatologists, as they involve areas with little fatty tissue, multiple tendons, little muscle volume, several bone structures, and inelastic skin [18].

Panattoni [19] proposed an ABCDE for the approach to trauma to the extremities:

1. The exclusion criteria for patients were as follows: antibiotic therapy, debridement, vascularity evaluation, revascularization, fasciotomy, and harmful pressure therapy.
2. Bone: external fixation, open reduction with internal fixation, bone shortening, bone flap or graft, temporary spacers.
3. Tendon contraction (contraction): tendon repair, graft, transfer, tenodesis.
4. Denervation: primary nerve repair, graft (allograft, autograft),
5. Coverage (Envelope): primary skin repair, free flap, local flaps, negative pressure therapy

Various techniques prevent substance loss, ranging from healing to free flaps, skin grafts, and local, regional, and distant flaps [20].

Levin LS [1] describes the reconstructive ladder with its levels of wound treatment. The reconstructive surgeon can go from a simple method of wound closure to a more complex step or, in numerous instances, simultaneously employ different steps to resolve a skin defect (Figure 1).

To measure functional capacity and pain, we used a Likert scale ranging from 1 to 5 (1 = not at all satisfied, 2 = slightly satisfied, 3 = neutral, 4 = very satisfied, 5 = completely satisfied).

The history of orthopedic surgery has evolved significantly lately, providing the impetus for optimizing reconstructive techniques. Reconstruction aims to guarantee functional and aesthetic results as early as possible while allowing early mobilization [20].

The literature includes numerous surgical techniques for covering the upper and lower extremities with musculocutaneous injuries. The Alcívar Hospital is recognized nationally as a clinic specializing in traumatology and orthopedics, constantly evolving and performing experiments to create innovative surgical techniques to resolve significant coverage defects.

Figure 1. The reconstruction staircase.

This work aimed to demonstrate our experience of combining plastic surgery techniques with orthopedic techniques (orthoplasty) for the surgical resolution of skin defects on the extremities and to measure the degree of postsurgical satisfaction using the Likert scale in patients who attended the traumatology service of the Alcívar Hospital from 2020 to 2022 in patients with traumatic orthopedic pathology.

Materials and methods

Study design

The present study was observational. The source was retrospective.

Scenery

The study was carried out in the traumatology and orthopedics service of the Alcívar Hospital - Guayaquil, Ecuador. The study period was from January 1, 2020, to December 31, 2022.

Participants

Patients with fractures with loss of coverage, fractures resolved with osteosynthesis, and fractures in whom flaps were used were included.

Variables

The variables were age, sex, cause, location, lesion size, and reconstruction technique.

Data sources/measurements

The source was indirect; an electronic form was used to fill out data from the institutional medical history of the patients who entered the hospitalization period. A review of the trauma and emergency unit records was performed. The information was confidential; no personal data was included in identifying the study subjects.

Biases

To avoid interviewer, information, and memory biases, the leading researcher always maintained the data with a guide and records approved in the research protocol. Observation and selection bias were avoided by applying participant selection criteria. Two researchers independently analyzed each record in duplicate, and the variables were registered in the database once their agreement was verified.

Study size

According to data from the Ministry of Public Health of Ecuador, 14,567 cases of fractures were registered in the province of Guayas in 2022. Approximately 10% of fractures require flaps, representing 1457 possible cases. The EPI Info™ program (version 7.2.5, CDC, Atlanta, USA, September 2022.) With a confidence level of 95% and a margin of error of 18%, the sample size was 30.

Quantitative variables

Descriptive statistics were used. The results are expressed as the frequency and percentage.

Statistical analysis

Noninferential statistics were used. The 95% confidence interval for a proportion was used to describe relevant frequencies.

Results

During the study period, 33 patients were evaluated. With ages between 4 and 71 years and an average age of 32 years, there was a predominance of males (28; 85%) over females (5; 15%). The majority of the cases were due to traffic accidents (21 [64%]; 12 were due to work accidents [36%]; it is essential to keep in mind that the majority of traffic accidents involved a greater prevalence of males ([Table 1](#)).

Table 1. Demographic data.

Sex	Total	Percentage
Male	28	85%
Female	5	fifteen %
Cause		
Work accident	12	36%
Car Accident	21	64%
Tip		
Superior	14	42%
lower	19	58%
Flap type		
Cutaneous	10	30%
Fasciocutaneous	11	33%
Muscular	8	25%
Vascular	4	12%

Table 2. Postsurgical functional assessment using the Likert scale.

Likert scale	Total	Percent-age
5	17	52%
4	16	48%
3	0	0%
2	0	0%
1	0	0%

Most patients presented with associated injuries, such as osteomyelitis, fractures, traumatic amputation, tendon rupture, and wound dehiscence, which were resolved promptly to obtain a recipient area of the flap under optimal conditions. A total of 14 (42%) surgical techniques were performed on the lower extremities, whereas 19 (56%) procedures were performed on the upper extremities (Table 1); these surgeries involved lesions that were between 1 cm and 12 cm in length and up to 1 cm to 15 cm wide.

Regarding the surgical technique used in the 29 patients, 10 (30%) had skin flaps, 11 (33%) had fasciocutaneous flaps (see Patient #1), 8 (25%) had muscle flaps, and 4 (12%) had vascular flaps (see Patient #2) (Table 1). Among the skin flaps, the dorsum of adjacent fingers (cross-finger), wide-based sliding on the leg, and a kite flap or PAMD (first dorsal metacarpal artery) were used. The fasciocutaneous flaps used in practice were pedunculated tubular inguinal, abdominal, or fasciocutaneous rotated or crossed flaps. Muscle flaps of the medial gastrocnemius, soleus, and hemisoleus were made,

and a reverse sural and ulnar artery flap was ultimately made. We are incorporating microvascular procedures into the institution.

According to the Likert scale, which measures functional capacity and pain, 17 patients (52%) were found to be completely satisfied (Likert 5), 16% were represented by 16 delighted patients (Likert 4), and the rest of the values were not altered (Table 2).

Discussion

Orthopedic surgeons face frequent situations requiring covering soft tissue defects in the extremities. Such coverage must be made as effective as possible. After timely infection control of the lesion and consecutive surgical cleaning of the devitalized tissue, we obtained a clean and healthy vascularized wound, a wound with granulation tissue, and a decrease in local edema. With the appearance of neo-epithelialization at the edge of the wound, one of the options offered by the reconstructive ladder was chosen [21].

In the approach to complex injuries in the extremities, the orthoplastic approach involves plastic, orthopedic, or microsurgical techniques, multidisciplinary assessment, rapid and individual decisions, and the elimination of countless skin lesions. The orthoplastic approach prevents amputation, reduces complications, and increases functional results, thereby improving patients' quality of life in the short and long term [22, 23]. Unfortunately, orthotopic surgery is not yet universally accepted [24].

The selection of the surgical technique according to the skin defect, regardless of the reconstruction, is vital for immobilizing the wound on a mobile or synovial joint and reducing it, preventing external forces from interrupting the healing process [10].

The first option for covering exposed bone, tendon, nerve, or blood vessel areas is local or regional flaps that use muscles or skin surfaces. This flap can be used for small or medium defects when the blood flow in the recipient area is unscathed. Total necrosis of the tissue that covers the skin defect should be avoided [25].

The transfer of a flap is ideal when there is a significant loss of soft tissue in the extremity with exposed bone, tendon, or osteosynthesis elements, avoiding, often, amputation of the extremity [9], in part favoring the preservation of exposed bone, reducing infection rates and promoting prompt healing [26].

The success rate of free flaps in treating lower extremity trauma ranges from 92% to 98% [11, 27]; in the present study, the Likert scale was used, with responses ranging from

4 to 5 indicating delight and delight, respectively, regarding reconstructive results.

Conclusions

Due to the extent of skin loss, the association with underlying lesions, and the possible infectious context, countless reconstruction techniques have been designed worldwide to avoid unnecessary amputations of the extremities; however, this approach is vital. A multidisciplinary orthopedic surgeon resolves skin defects, accelerating definitive skeletal fixation and restoring limb form and function.

Patient #1: A). A 22-year-old male patient who was involved in a work accident (with a paper printing machine) presented a loss of coverage of approximately 8x11 cm on the dorsal aspect of the left hand after consecutive cleanings plus raphia of the extensor tendon of the index and middle fingers. **B)** Abdominal flap fasciocutaneous **C)** Flap release after two weeks.



Patient #2, A) A 22-year-old patient who suffered a motorcycle accident as a driver, with a loss of coverage of approximately 4x2 cm in the interdigital space between the thumb and index finger of the right-hand **B)** consecutive surgical cleanings plus osteosynthesis with pins Kirchner **C)** comet flap or PAMD (First Dorsal Metacarpal Artery). **D)** Free graft in the flap donor area.



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Statements

Ethics committee approval and consent to participate

The ethics committee of the Alcívar Hospital approved the study.

Publication consent

The authors have permission to publish from the patients in the study.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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