

Evaluation of Micro-Needling as a Flap Preconditioning Modality: A Split-Flap Study

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ABSTRACT

Background: Distal flap necrosis is a common problem that is frequently encountered by plastic surgeons. Micro-needling with a handheld roller device is a minimally invasive modality that is proposed to improve distal flap circulation, it causes localized dermal injury with rupture of fine dermal and subdermal capillaries. As a result of platelet extravasation, activation and growth factors release, neoangiogenesis occurs which in turn enhances flap circulation. Our current study aims to evaluate the efficacy of micro-needling as a minimally invasive delay technique.

Methods: 20 patients with various defects who met our inclusion criteria were included. The derma-roller device was used as a flap delay modality. This was done preoperatively, three days and on the night before surgery. The flap was divided into equal halves; The Study half was exposed to preconditioning by micro-needling while the control half wasn't. All patients were followed-up for one month postoperatively.

Results: The mean surface area of defect (length multiplied by width in cm) was 38.9 (± 20.37) the minimum was 15 while the maximum was. All patients' defects were covered by random pattern cutaneous or fascio-cutaneous flaps. The mean surface area of flap used for coverage was 59.85 (± 23.78) the minimum was 28 while the maximum was 128. The average surface area of distal flap necrosis in the control side was 35% meanwhile it was 20% in the study side.

Conclusions: Flap preconditioning with micro-needling might decrease distal flap necrosis and improve flap survival in random pattern cutaneous and fasciectomy flaps. It is a simple, minimally invasive modality that could be done as an out-patient procedure.

Key Words: Micro-needling – Derma-roll – Flap delay.

INTRODUCTION

Despite the great advance in the wound management, pedicled flaps remain an effective treatment modality for the coverage soft tissue defects particularly traumatic raw areas. However, distal flap necrosis remains a common complication that is frequently encountered by plastic surgeons.

On the level of flap micro-circulation, when a random pattern cutaneous or fascio-cutaneous flap is harvested, capillary bed disruption leads to blood flow abnormality with hemodynamic instability, which might progress eventually to significant reduction of distal vascular perfusion. Ultimately, this might be manifested clinically as partial flap necrosis. Therefore, plastic surgeons give great attention to improve flap circulation prior to flap harvesting. For this reason, the effects of various pharmacological agents as well as different surgical modalities had been studied and discussed extensively in literature [1].

Skin micro-needling procedure is a newly proposed technique that could be used as a flap delay modality. It is commonly used nowadays in cosmetic practice such as acne scar management, skin rejuvenation, hair implantation, and many other facial cosmetic procedures with good promising results [2,3].

Localized dermal injury produced by micro-needling result in rupture of fine subdermal blood vessels. Posttraumatic platelets' activation lead to the release of multiple growth factors, eventually better blood circulation is achieved [4].

Literature review reveals multiple animal trials that were conducted to investigate the efficacy of micro-needling as a minimally invasive flap delay modality. However, up to date, there is no published study that evaluate its safety and efficacy in humans [4,5,6].

PATIENTS AND METHODS

This study was conducted in accordance with the guidelines contained within the Declaration of Helsinki. Following obtaining institutional ethical committee approval, admitted Patients to Plastic and Reconstructive Surgery Department with post-

traumatic defects who were candidate for flap coverage between September 2019 and April 2019 were included, provided that they met our inclusion criteria. All patients provided written informed consent before being enrolled in our study.

To avoid bias due to any other offending factor that could be a reason for flap vascular compromise; Patients with peripheral vascular disease, chronic illness (i.e DM), patients suffering from autoimmune diseases, patients on immunosuppressants, previous irradiation to the same angiosome, failure of previous flap coverage or previous flap surgery at the same angiosome were excluded.

Three days preoperatively, the flap was marked and divided into halves (Study and Control sides). The flap was divided parallel to its longitudinal axis to ensure symmetry and unify all factors affecting blood supply for both sides. Hence, if any difference was noticed could be attributed to micro-needling effect only.

Micro-needling was performed using manual roller device (Fig. 1) on the study side only. In order to be able to reach the subdermal capillary plexuses, a roller device with 2.5mm needles length was used. This was performed in horizontal, vertical, and oblique directions (Fig. 2) till pinpoint bleeding was noticed (Fig. 3). The process was done on the 3rd preoperative day and the night of surgery.

Postoperatively, flaps were monitored regularly and evaluated objectively for any signs of congestion or vascular compromise. If flap congestion was noticed, micro-needling was used as a drainage procedure on the first and third post-operatively days. On the seventh postoperative day, any recorded distal flap necrosis was measured topographically, and the size was compared across both sides of the flap.

Data were analyzed using mean, median, standard deviation, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data.



Fig. (1): Handheld derma roller device which had been used for flap preconditioning (DRS, Skin Care Titanium Dermaroller 540 Micro, Allfond Co. Limited, Guangzhou, China).



Fig. (2): Preoperative flap design with the division of the flap along with its longitudinal axis.



Fig. (3): Micro-needling was performed in horizontal, vertical, and oblique directions till pinpoint bleeding occurred.

RESULTS

Twenty patients (12 males & 8 females) (Fig. 4) presented to the plastic and reconstructive surgery department, with various injuries and exposed structures (bone, vessel, nerve) were included in this study. The mean age was 34.15 (±11.30) minimum 18 and maximum 55 years. The mean BMI was 27.50 (±4.42) with the lowest BMI was 19 and the highest was 35. 50% of the included patients were smokers. (Table 1).

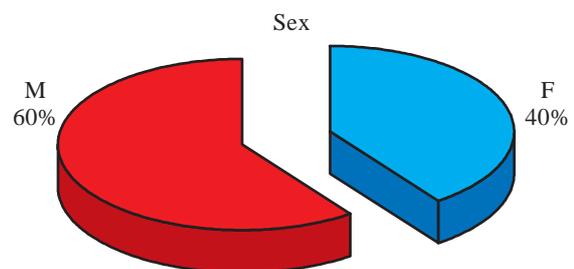


Fig. (4): A Pie chart showing sex distribution in patients included in the study.

Table (1): Showing demographic data (Age, Sex) of patients participated in this study.

	Mean	Standard Deviation	Median	Minimum	Maximum
Age (years)	34.15	11.30	34.00	18.00	55.00
BMI (Kg/m ²)	27.50	4.42	27.50	19.00	35.00

The mean surface area of the defects was 38.9cm (± 20.37) with a minimum of 15cm and a maximum of 98cm while the mean surface area of the flaps was 59.85cm (± 23.78) with a minimum of 28cm and maximum of 128cm. (Table 2).

In all patients, there was no total flap loss, however partial flap necrosis occurred in 20% of the study side and 35% of the control side. The mean surface area of distal necrosis was 1.5 (± 0.58) with a minimum of 1 and a maximum of 2cm for the study sides whereas the mean was 1.57 (± 0.79)

with a minimum of 1 and maximum of 3cm for the control side. (Table 3).

Table (2): Surface area of the wound. The surface area of the flap, duration of recovery.

	Mean	Standard Deviation	Median	Minimum	Maximum
Surface area of wound (cm)	38.90	20.37	34.00	15.00	98.00
Surface area of flap (cm)	59.85	23.78	55.00	28.00	128.00
Duration of recovery (weeks)	2.60	1.35	2.00	1.00	6.00

Table (3): Demographic distribution of the surface area of necrotic areas.

	Study side					Control side				
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum
Surface area of necrosis (cm)	1.50	0.58	1.50	1.00	2.00	1.57	0.79	1.00	1.00	3.00

DISCUSSION

Despite Recent advances in flap surgery, distal flap necrosis remains a serious problem that is frequently encountered by plastic surgeons. Flap delay techniques had been used to overcome not only the distal flap necrosis but also to increase the flap dimensions when needed [7].

The concept of vascular delay is dated back to the sixteenth century. However, the detailed microvascular mechanisms had been not popularized until the nineteenth century. Since that, many authors had proposed different modalities for achieving more convenient simple techniques which can be easily incorporated in daily practice with accepted reproducible results [8].

Despite non-surgical or biochemical delay as nominated by many authors had been reported extensively in literature, Surgical delay remains the gold standard until now. It ranges from a partial marginal incision, ligation of non-dominant pedicle, and partial or complete flap elevation. Although the biochemical delay technique avoids frequent surgical procedures; by the administration of various drugs. However, the systemic action and the side effects remain the main drawbacks of such techniques.

One of the most effective delay techniques is ischemic preconditioning. In 2001, Matsumura et al., conducted a study to evaluate different preconditioning methods on eighteen male Sprague Dawley rats. The effect of ischemic preconditioning by pharmacological agents; local injection of Adeno-

sine in the cranial half of the flap had been compared to proximal vascular clamping. Their results showed a 17% increase in flap survival with pharmacologic preconditioning versus 13% only with surgical clamping [10].

Despite, the encouraging results of Matsumura et al., which demonstrated that flap preconditioning either ischemic or pharmacologic could improve flap survival. These techniques are not applicable to all types of flaps in daily practice; e.g. in random-pattern flaps, there is no nominated vascular pedicle to be clamped. In addition to technical errors that might result from excessive or aggressive clamping, which could lead to complete vascular compromise. Also, Adenosine administration could evoke unexpected side effects; chest pain or cardiac arrhythmia. That's why many authors had proposed that its use as a preconditioning method should be re-evaluated [10].

Based on the same principles, a recent concept had been proposed, which is minimally invasive delay techniques. These concepts are based on local mechanical alteration of flaps' vascular territories. Thus, many authors adopted this concept and reported its efficacy as well as its reliability [11,12,13].

To search for more reliable convenient modalities, many authors had reported the efficacy of micro-needling as a minimally invasive delay technique. Some of them evaluated the micro-needling as a solo modality, whereas others evaluated it in combination with some pharmacological agents.

The first report about micro-needling as a delay modality dated back to 2009, when Yang & Kim studied the effect of topical application of heparin with micro-needling on the viability of random pattern dorsal skin flap in hairless mouse. They measured the capillary blood flow by laser doppler flowmetry, that showed a positive correlation with flap survival rate. However, they correlate their results to the topical effect of heparin on the capillary flow rather than the micro-needling itself [6].

In 2013, Baris et al., used the micro-needling as a solo modality for increasing flap viability. They evaluated its efficacy topographically, scintigraphically, and histopathologically. They performed the micro-needling on rats' dorsal cutaneous flaps; On the 3rd preoperative day, on the day of surgery, and postoperatively on the third and sixth days. They measured the surface area of flap necrosis on the seventh postoperative day topographically and scintigraphically. Then, the amount of neovascularization and number of vascular structures within the papillary dermal layer were counted histopathologically. This study showed that the micro-needling method which is applied directly to the flap's surface could be faster, safer, and more effective therapeutic modality to increase flap viability. They concluded that localized dermal injury produced by micro-needling result in rupture of fine subdermal blood vessels. Posttraumatic platelets' activation lead to the release of multiple growth factors, eventually better blood circulation is achieved [4].

In the current study, we applied the same technique. However, On the 3rd postoperative day, flaps that showed good outcome with no distal necrosis, micro-needling wasn't applied again. For flaps that showed early signs of congestion postoperatively, micro-needling was used for couple of times, where it acts as a drainage procedure. Hence, this might improve flap survival.

In 2015, Akcal et al., studied the effect of platelet-rich plasma "PRP" that was combined with micro-needling on congested flaps with significant venous outflow compromise in rats. They concluded that micro-needling combined with PRP might be an effective treatment modality to reduce congestion, interstitial edema and increase neoangiogenesis in venous congested skin flaps. Their results suggested that the growth factors that might be released from activated platelets in addition to the micro-needling induced sensory nerve fibers' activation, increase tissue survival and regeneration [14].

In 2017, Wang et al., performed an experimental study to evaluate the effectiveness and safety of electrical micro-needling in improving the survival of perforator flaps in an experimental rat model. They concluded that preconditioning with electrical micro-needling could improve perforator flap survival by increasing flap perfusion and angiogenesis [5].

In the current study, we used manual micro-needling due to the unavailability of electrical micro-needling. Moreover, hand held roller device is more controlled and more cost-effective method that can be used by the patients themselves. Hence, it could be done as an out-patient procedure. Thus, decreasing the hospital stay, and hospital-acquired infections. It required minimal preoperative preparation and a simple technique that can be easily demonstrated to the patients.

On the other hand, with micro-needling, there was no systemic administration of any pharmacological agents. Thus, it could avoid hypersensitivity reactions and other side effects that might occur with pharmacological preconditioning methods.

This study had showed that micro-needling might decrease distal flap necrosis and eventually improve flap survival. However, the small sample size within this study could be a limiting factor. Thus, we recommend a study on a bigger scale that could be more informative in a statistical term.

Disclosure:

None of the authors have any conflicts of interest or financial interest in any of the products that had been used or mentioned in this article.

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