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EMLA and Water Immersion Cause Similar Vasodilatation in Replanted Fingers

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Background. **Skin wrinkling on water immersion is a reliable and simple test of sympathetic innervation. The eutectic mixture of local anesthetic (EMLA) cream has been shown to induce near identical clinical wrinkling scores and reduction in digit blood flow as that following water immersion in people with normal sympathetic innervation. This study was designed to investigate the vasomotor response to EMLA in replanted fingers that had poor sympathetic innervation.**

Methods. **Laser Doppler imaging (PeriScan PIM II; Perimed AB, Stockholm, Sweden) was used to detect perfusion changes in the pulps of fourteen replanted fingers before and after 0.5 g of 5% EMLA cream application and water immersion in a 40°C normal saline for 30 min, respectively. Comparisons were made with the contralateral corresponding normal fingers.**

Results. **After water immersion and EMLA application, all of the normal fingers showed a considerable and similar decrease in blood perfusion that demonstrated in the absolute perfusion units (pU) (baseline: 1.57 ± 0.33 pU, after water-immersion, 1.19 ± 0.22 pU, $P < 0.001$; decrease: 23.6 ± 7.7%, after EMLA application: 1.20 ± 0.18 pU, $P < 0.001$; decrease: 22.4 ± 8.9%). In contrast, all of the replanted fingers showed a statistically significant vasodilatatory response (baseline: 1.20 ± 0.29 pU, after water-immersion: 1.36 ± 0.28 pU, $P < 0.001$; increase: 15.2 ± 9.1%, after EMLA application: 1.38 ± 0.27 pU, $P < 0.001$; increase: 16.8 ± 9.1%).**

Conclusions. **EMLA and water immersion both cause vasodilatation and no skin wrinkling in replanted fingers. These results imply that intact sympathetic nerve function is required to induce the vasoconstrictive effect of EMLA.** © 2007 Elsevier Inc. All rights reserved.

Key Words: **EMLA; finger replantation; skin wrinkling; sympathetic denervation; water immersion.**

INTRODUCTION

Water-immersion skin wrinkling is an indicator of limb sympathetic function [1–3]. It has been suggested that wrinkling is related to digital vasoconstriction controlled by skin sympathetic nerve activity [4–7]. Through vasoconstriction, the large numbers of glomus organs that exist in the distal digit pulp, shrink, lose volume, and pull the superficial skin structures downwards through epidermal anchoring to produce wrinkling [5–7]. It has also been observed that a eutectic mixture of local anesthetic (EMLA) cream induces almost identical clinical wrinkling scores and reduction in digit blood flow to that of water-immersion in normal persons [5], thus making the EMLA cream patch test has the potential to be well developed into a useful screening test for sympathetic vasoconstrictor function of the hand [5]. EMLA causes a biphasic vascular response comprising of initial blanching and vasoconstriction lasting over 90 min, followed by erythema and vasodilatation for application times longer than 3 h [8–10]. Through interaction with voltage-gated Na^+ and K^+ channels, the amide local anesthetics lidocaine and prilocaine have a neuronal blocking effect on motor and sensory neurons [11]. In addition, EMLA is also speculated to cause vasoconstriction through direct effects on calcium channels present in post-ganglionic neurons and possibly smooth muscle cells [8, 12, 13]. However, the complete mechanism remains unclear.

Before using EMLA cream as a screening test for sympathetic function of the hand as suggested by some

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authors [5], it is important to determine both the effect and mechanism of action of EMLA in a variety of neuropathies. O'Riain has reported that replanted fingers are unable to demonstrate wrinkling after water immersion (O'Riain's sign) [14]. In our previous study using laser Doppler perfusion imaging, we demonstrated significant vasodilatation accompanied by no wrinkling in replanted fingers following immersion, implying poor sympathetic innervation after replantation [15]. The present study aimed to clarify the effect and mechanism of action of EMLA on digital venoarteriolar response by investigating the change in digital perfusion after application of EMLA to replanted fingers and contralateral corresponding normal fingers. Perfusion was assessed using laser Doppler perfusion imaging and was compared to perfusion changes after water immersion.

PATIENTS AND METHODS

The protocol was approved by our hospital's Institutional Review Board and all patients completed informed consent before participating in the study. We recruited 14 patients (2 women and 12 men, age range 22–55, mean age 32.4 ± 9.3 years) who had sustained a traumatic complete amputation and undergone successful microscopic replantation, including bilateral digital neurorrhaphy. A combined total of 14 fingers were replanted at Chang Gung Memorial Hospital, Kaohsiung. Only those who had undergone replantation longer than 1 year ago were included in this study, with the mean time after replantation being 16.4 ± 4.5 months. Patients suffering from diabetes mellitus, heart disease, hypertension, or a recent hand wound were excluded. All of the patients were labors with active activity without particular medications during the tests. The finger that underwent replantation will be referred to as the replanted finger. Its corresponding normal finger on the contralateral undamaged hand was used as a control for comparison.

Laser Doppler Perfusion Imaging

Laser Doppler perfusion imaging is a well known technique for assessing tissue microcirculation in a continuous and non-invasive way [16, 17]. In this study, the Laser Doppler Imager (PeriScan PIM II; Perimed AB, Stockholm, Sweden) with the same imaging setting was used to measure the perfusion of the pulps of replanted and control fingers after EMLA application or water immersion. Before imaging the laser was warmed up for 30 min and calibrated by placing the probe against a white reflecting surface according to the manufacturer's instructions. The scanner head was held 15 cm above the imaged surface during the procedure. Once scanning was completed, a color-coded perfusion image was displayed on a connected computer screen next to the corresponding photographic image. The laser Doppler signal of the scanned image was transferred to another computer and analyzed using LDPIwin software (Perimed AB). This software enables statistical analysis of perfusion value profiles within a region of interest, i.e., the pulps, in circular areas of the same size containing the same number of pixels. The output signal was recorded and expressed as arbitrary perfusion units (pU) [16, 17].

EMLA Application

Testing was performed in a quiet room with a room temperature between 26 to 28°C. All of the patients were seated upright with their hands resting on the table. Digital skin surface temperature was measured using an infrared thermometer before the procedure (Exergen DT-1001, Watertown, MA). 0.5 g of 5% EMLA cream (which is made up of 2.5% lignocaine and 2.5% prilocaine) from Astra Pain Control AB, Sweden was applied over the distal digit tips of the replanted fingers and then covered with a Tegaderm occlusive dressing. After 30 min, the dressing and all of the EMLA cream were removed quickly and softly, after which the hand was placed under the Laser Doppler Imager and the scan performed. Only one scan was taken. After a 60-min break, EMLA was applied to the contralateral corresponding normal finger and a scan performed using the same above-mentioned procedure.

Water Immersion Test

The water immersion test was performed in the same room as the EMLA application on the following day in all patients. With the subject sitting in an upright position, the injured hand was immersed up to the distal forearm in a 40°C normal saline (0.5 mol/L NaCl) water bath, which is considered to be the optimal immersion fluid and temperature for wrinkling [5, 6]. The salt solution was kept at 40°C with a water heater. After 30 min of immersion, the hand was quickly taken out of the water bath, gently dried, placed under the Laser Doppler Imager, and the scan performed. The same procedure was carried out on the contralateral normal hand one hour later.

Data Analysis

The perfusion values of the test fingers before and after EMLA application and water immersion are given along with their standard deviations. The presence of statistically significant differences in the data were analyzed using SPSS statistical software (version 11.5; SPSS Inc., Chicago, IL) and by calculating paired Student's *t*-tests. The level of statistical significance was set at $P \leq 0.05$.

RESULTS

The skin surface temperature immediately before EMLA application or water immersion did not differ significantly between patients. All of the control fingers demonstrated wrinkling after water immersion and EMLA application. In contrast, no remarkable wrinkling was found in any of the 14 replanted fingers (Fig. 1). All of the control fingers showed a considerable and similar

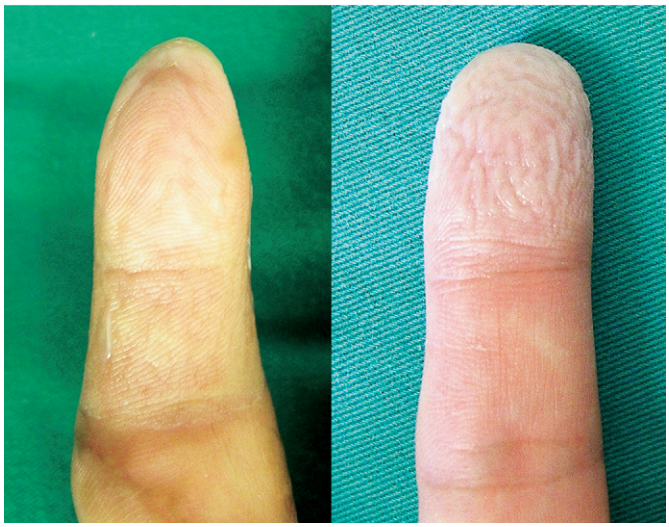

FIG. 1. Remarkable skin wrinkling was noted in the normal finger but not in the replanted finger after EMLA application (left: replanted finger; right: normal finger). (Color version of figure is available online.)

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