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Investigating Skin Penetration Following Needle-Free Injection Combined with Fractional Laser and Subcision

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Dear Editor:

Pneumatic needle-free injection devices are widely used for skin rejuvenation and scar treatment purposes[1,2]. They are often used in combination with other treatment methods in order to increase treatment effectiveness[3,4]. Cadaver studies confirmed that injection fluid enters the skin at different depths and shapes depending on pressure when using only a pneumatic needle-free injection device. However, it has not been determined what occurs when performing such treatments together with other methods[5]. In this study, we generated models for subcision and fractional laser treatments, which are used widely for scars and wrinkles, and tested them on a tissue-mimicking (TM) phantom.

We pneumatically injected hypertonic glucose solutions at a 20% concentration into a TM phantom in order to assess fluid infiltration tendencies and patterns. We generated the TM phantom in order to mimic tissue responses induced by pneumatic injections under diverse conditions. We prepared a transparent gelatin phantom as described in a previous study with only minimal modification by mixing 12.5% (w/v) gelatin (Sigma-Aldrich, St. Louis, MO, USA) with distilled water[6]. We promptly poured the combination into a polycarbonate housing after degassing and let the mixture stiffen in a refrigerator for 12 hours at 39.2°F (4°C). We then built a polycarbonate frame to accurately replicate the injection of experimental solutions under all test circumstances. This required the instrument's handpiece to be held by the frame. The injection button was controlled remotely to ensure the stabilization of the handpiece. A transcutaneous pneumatic injection device (SheMax™; Shenb Co., Ltd., Seoul, Korea) was used for injections. The injections into the TM phantom were performed with a nozzle diameter of 200 μm, and at a pressure of 3.63 bar 0.01 ml/injection.

After treatment with the fractional laser, we used the pneumatic needle-free injection device to perform injections under the 4 following conditions: 1) Without any resistance, TM phantom only (Group 1); 2) with 0.02 m of polyethylene vinyl applied to cover the TM phantom, in order to replicate the conditions of the epidermis, TM phantom + polyethylene vinyl (Group 2); 3) TM phantom + polyethylene vinyl + 120 μm hole (Group 3); and 4) TM phantom + polyethylene vinyl + 430 μm hole (Group 4). The 120 μm holes were created using the DeepFX handpiece of the UltraPulse Encore (Lumenis Inc., Palo Alto, CA, USA), and the 430 μm holes were generated using the ProFractional-XC (Sciton Inc., Palo Alto, CA, USA).

In order to observe outcomes of using pneumatic needle-free injection devices after subcision, we performed injections of the TM phantom after subcision at its center with a 18 gauge needle.

When using a pneumatic needle-free injection device after performing fractional laser treatment, the depths that the injections reached were: 5.7 cm (Group 1), 3.2 cm (Group 2), 4.5 cm (Group 3), and 4.8 cm (Group 4) (Fig. 1). We confirmed that the injected material would diffuse in the subcision plane when using a pneumatic needle-free injection device after subcision (Fig. 2).

Pneumatic needle-free injections are a new method for in-

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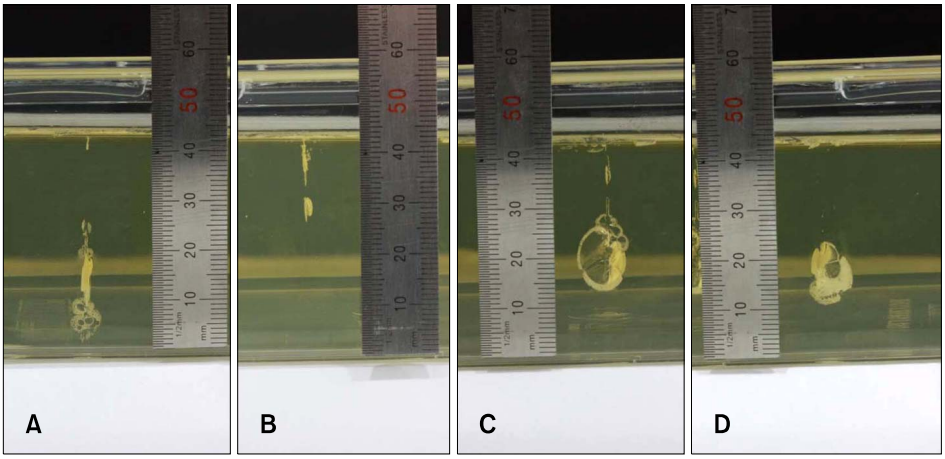

Fig. 1. (A) Tissue-mimicking (TM) phantom only (Group 1), penetration depth: 5.7 cm. (B) TM phantom + polyethylene vinyl (Group 2), penetration depth: 3.2 cm. (C) TM phantom + polyethylene vinyl + 120 μm hole (Group 3), penetration depth: 4.5 cm. (D) TM phantom + polyethylene vinyl + 430 μm hole (Group 4), penetration depth: 4.8 cm.

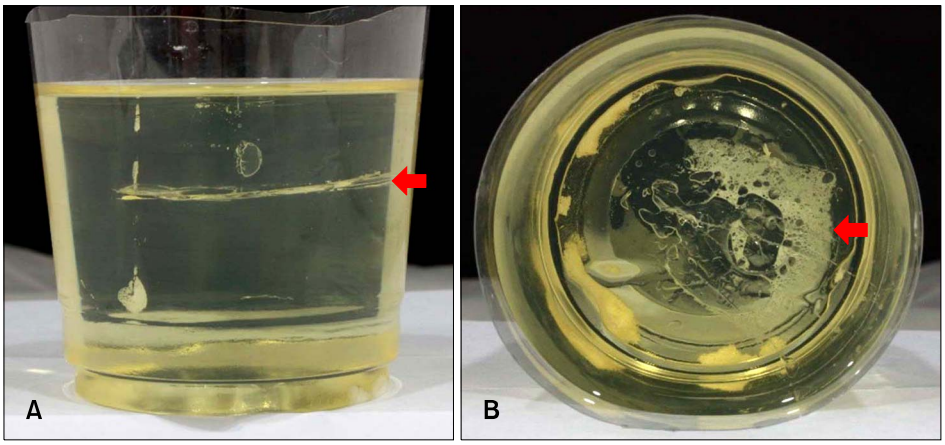

Fig. 2. (A) Lateral view. Compared to the control on the left, injections into the area of subcision on the right only reached a superficial depth. (B) Upper view. The solution diffused widely in the subcision plane. Red arrows: subcision plane.

troducing diverse substances into the skin. Such substances may include aesthetic medicines, hyaluronic acid, botulinum toxin, and placental extracts. Studies of these devices have recently been performed, and are beginning to reveal positive effects on scar remodeling by stimulating the fibroblasts via micro-trauma and activating neocollagenesis, in addition to administering extended skin planes[1,7]. In studies using mice, pneumatic needle-free injections promoted collagen synthesis and enhanced dermal thickening[8]. As proof of the effectiveness of pneumatic needle-free injections accumulates, this method is now being applied for skin rejuvenation and scar treatment. Furthermore, it is being tested for combination therapy with other forms of treatment. Treatments used in combination therapy include fractional laser and subcision. We previously examined the phenomena that occur when these methods are used together with pneumatic needle-free injection[9,10].

When using pneumatic needle-free injection devices after using a fractional laser, we have found that the material reaches greater depths with all other conditions being equal. We also found that the larger the hole size created by the fractional laser, the greater the depth the material reached. Therefore, when using a pneumatic needle-free injection device after using a fractional laser, if a clinician desires to inject material at the same depth as when a fractional laser was not used before the injection, the clinician would need to apply less pressure, and the pressure is expected decrease as the hole size grows larger.

Using a pneumatic needle-free injection device after subcision results in the diffusion of the injected material as it enters the subcision plane. Therefore, when performing subcision, it is important to cautiously define the depth to which one desires to have the material diffuse, and to control the pressure of the injection device so that the material will reach at least the depth of the subcision plane. When using this method, clinicians are expected to be able to introduce materials evenly at the subcision plane when injecting materials that have a low cohesivity and high loss modulus (G″). This method is also expected to be useful for preventing injected material from penetrating to undesired depths.

The limitations of this study are that we were only able to perform our experiments on the TM phantom, and therefore may not be generalizable to predict the results of injections performed on actual human skin. In addition, as polyethylene vinyl cannot exactly represent the resistance characteristics of the epidermis, the results of this study may only cautiously be applied for the treatment of actual patients. In this study, we sought to reveal phenomena that can occur when using pneumatic needle-free injection in company with other methods of treatment. In the future, there will be a need to observe differences in efficacy and histologic changes when performing combination therapy on actual human patients.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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