Video Super-microsurgery Amplified using Close-up Lens Filter on the Operative Field Camera: Preliminary Report

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Background: Super-microsurgery has widely spread due to the improvement of high magnification microscopes. The cost of multiple microscopes is high. Furthermore, the microscope heads are too large to fit in multiple surgical fields for pediatric patients. We adapted a 2-dimensional magnification system for performing lymphatic venous anastomosis on pediatric lymphedema cases.

Methods: We attached a close-up lens filter to the suspended camera (CHZ-1,360-PTR camera, Carina system, Tokyo, Japan) in the operative field. This was done to achieve 26× magnification using a small camera head, making it possible to perform super-micro anastomoses. Anastomoses time, scar length, and lymph vessel diameters were measured, and the outcomes were statistically analyzed and compared with the contralateral side.

Results: Four pediatric lymphedema patients underwent the aforementioned technique, using the multisite microscopic approach. All anastomoses were completed within 20 minutes. The results were not significantly different from the conventional microscopic lymphatic venous anastomosis.

Conclusion: This system is advantageous because (1) it has less costly initial investments; (2) it requires a small camera head, which provides available space for the multisite microscopic approach even for pediatric patients; and (3) it allows for a wider surgical working space. (Plast Reconstr Surg Glob Open 2018;6:e1875; doi: 10.1097/GOX.0000000000001875; Published online 6 August 2018.)

INTRODUCTION
Lymphatic venous anastomosis (LVA) is 1 of the most frequently chosen surgical options for lymphedema treatment. LVA is suitable for both adult and pediatric patients. A fine magnification tool for completing the procedure is mandatory, which may include surgical microscopes. However, surgical microscopes typically use a large camera head and are expensive. It is well-known that multi-site surgeries for lymphedema treatment are advantageous; however, only a few hospitals can afford to purchase multiple fine microscopes. Furthermore, it is difficult to conduct the multiple microscope approach because the large camera heads interfere with each other due to the short extremities of pediatric patients. Herein, we applied a close-up lens filter attached to the room where the surgical field camera was suspended using a smaller head. This is an inexpensive alternative to 2-dimensional magnification for super-microsurgical procedures.

MATERIALS AND METHODS
We used our surgical field suspended camera system (CHZ-1360-PTR camera, Carina system, Tokyo, Japan), with an attached close-up lens filter (Kenko 58 mm close-up lens +3, Tokyo, Japan) to achieve 26× magnification for the procedure (Fig. 1). The operative field light emitting diode light was focused on the surgical site during procedures using the present magnification system.

Out of 21 sequential congenital pediatric lymphedema patients who were referred to our clinic from 2015 April to 2017 October, unilateral cases, other than lower extremities
and lymphangiomas, were excluded. All 4 patients who were included had congenital bilateral lower extremity lymphedema (1 male and 3 female), aged from 10 months to 8 years (mean age, 4.7 years). These patients were diagnosed through positive dermal backflow patterns with indocyanine green lymphangiography. Under general anesthesia, we performed bilateral lymphatic venous anastomosis (LVA) in all patients. Eight anastomoses were performed (Table 1) under the present magnification system, and 8 under surgical microscope (OPMI, Pentero900, ZEISS, Japan).

All the anastomoses were performed in an end-to-end manner, using 11–0 or 12–0 Nylon and 3–6 sutures, depending on the size of the vessels. The 2 mm piece 6–0 or 7–0 Nylon was inserted in both the vein and lymphatic vessel during sutures on the anastomoses as intravascular stenting technique.[1] The same surgical equipment and technique was used on all the anastomoses. All the anastomoses using the present camera system were done by the corresponding author, whereas the other procedures were performed under a microscope when an experienced surgeon was available at the same time (Fig. 2). The remote for the camera control system was put in a sterilized plastic bag; therefore, the surgeon could focus on magnifications during procedures requiring anastomoses.

Local anesthesia injection, skin incision, lymphatic detection, and brief dissection (until the lymph vessel could be free from the surrounding adipose tissue) was performed using a surgical loupe (2.8× magnification) to reduce the total surgical time. All the other fine procedures, such as dissection (fat removal from vessels), preparations, and anastomoses were done under the present camera system with accompanying observation monitors. The lymphatic vessel diameters, time under the camera system, and last skin scar length were measured to determine surgical outcomes. Statistical analysis was also conducted using Student’s t test.

This study was approved by the institutional review board. In all cases, informed consent was provided by patient’s guardians.

RESULTS

Four patients underwent 16 anastomoses in this study (8 anastomoses each under each magnification system). In total, 4 anastomoses were performed in all patients. The anastomoses using the close-up lens system was used as follows: 3 anastomoses in 1 patient, 2 anastomoses in 2 patients, and 1 anastomosis in 1 patient (Table 1). No anastomoses were performed under the novel camera system requiring surgical microscopic assistance. No complications were detected 6 months postoperatively.

Six anastomoses were performed on the dorsal pedis, and 2 were performed on the calf under the camera system. The outer diameter of the lymphatic vessels was between 0.15 and 0.55 mm (mean, 0.32 mm). The anastomoses time was between 13 and 20 minutes (mean, 15.9 minutes), and the skin incision length was between 1.0 and 1.8 cm (mean, 1.48 cm). None of these outcomes showed significant differences between the camera system and microscopic anastomosis (Table 2).

DISCUSSION

Multisite LVA for adult patients were reported as an effective approach for lymphedema.2,3 The disadvantages of the multi-site approach include the necessity of multiple surgical microscopes and crowded surgical space. In contrast, the SEKI method was reported to be effective in single anastomoses.4 However, its efficacy for primary pediatric lymphedema is unclear. Microsurgery under the 2-dimensional camera system was reported previously as video microsurgery,5–7 or endoscope-assisted anastomosis.8,9 Recently, a 3-dimensional camera was used for a microvascular anastomosis trial. Observing through a monitor was associated with better comfort (better ergonomics)10 compared with a microscope. The smallest diameter of anastomosed vasculature reported in the microsurgery trial was 0.6 mm, which is considered as “super-microsurgery,” defined by anastomosed vessels of 0.3–0.8 mm.11 Yet, it was larger than our cases. The range of diameter of pediatric lymphatic vessels in this report is 0.15–0.55 mm. Therefore, this is the first clinical report that successfully demonstrated “beyond-super-microsurgical” anastomoses. Using our techniques in this report, it enables us to perform LVA on tiny vessels in pediatric cases with lower cost and good prognosis.

Table 1. List of the Patients and its Numbers of LVA under Which Magnification Was Applied

| No. | Age (y, mo) | Sex | Lateral | Diagnosis       | Complication     | Video System | Side | Microscope Anastomosis |
|-----|-------------|-----|---------|----------------|------------------|--------------|------|------------------------|
| 1   | 0, 10       | M   | Bilateral | Congenital LE | Constricted band | L            | 3    | 1                      |
| 2   | 2, 11       | F   | Bilateral | Congenital LE | None             | R            | 2    | 2                      |
| 3   | 6, 4        | F   | Bilateral | Congenital LE | None             | L            | 2    | 2                      |
| 4   | 8, 8        | F   | Bilateral | Congenital LE | None             | R            | 1    | 3                      |
The close-up lens filters, also called macro filters, are secondary lenses that are used for macrophotography without utilizing specialized primary lenses. Telephoto lenses can be customized by simply attaching close-up lens filters to the front of the primary lenses. These are classified by optical power, ranging from +1 to +7 diopters. Various types of close-up lens filters are sold in the market. Prices may vary, but the lenses usually cost between $10 and $100. The cheapest material costs only $10 and is enough for adequate filtration for performing LVA. This is inexpensive compared with purchasing a new surgical microscope, which costs between $10 000 and $40 000.

By simply attaching the close-up lens to the suspended camera system in the room, a magnification of about 26× is achieved, which is enough to perform LVA. This is the first report on the use of a 2-dimensional magnification system for pediatric lymphedema LVA, and the clinical success of anastomoses of tiny vessels with an outer diameter of 0.15 mm. There are a number of advantages to this system: (1) inexpensive start-up cost; (2) a wide working space can be provided; (3) the magnification can be increased if required; (4) focal adjustments can be done automatically using our system; and (5) any kind of operative field camera system can possibly be used to achieve enough magnification sufficient for performing LVA. Depending on which lenses are used, the most optimal focal length can be determined. In our experience, +2 or +3 diopters of the close-up lens filter was suitable for the surgical field in the room with a suspended camera system, with 20–40 cm being the closest focal distance for applying LVA.

The wide working space is suitable for the pediatric patients because the surgical site is usually smaller than in adults (Fig. 4). We determined that surgical microscopes and this system can be used to operate at the same time even for pediatric lower extremity cases (Fig. 2). The distance between the patient’s skin and the camera lens were much longer compared with a microscope. This allows for decreased chances for needlestick injuries and needle loss.

In case the lymphatic vessels are much smaller, a much higher magnification than 20× was required to achieve a larger view for avoiding occlusion due to suturing of the posterior wall while creating an anastomosis. In the present system, the magnification can be increased by changing only the close-up lens. The close-up lens attachment is universal and can be widely used.

The limitation of this study includes a small number of cases. Furthermore, the main magnification power may be limited to the potential of the room camera. Additionally, the system head angle is not as adjustable as with microscopes. Therefore, the camera position and the surgical plane field are important considerations before surgery. The time and scar length may be biased due to the fact that all procedures under the camera system were performed by a single surgeon. Furthermore, the present cases were cases of congenital lymphedemas, which are niche diagnoses. However, this system is potentially applicable for a wider variety of cases that require magnification, such as adult patients with lymphedema, microsurgery, or perforator flap reconstructions. Furthermore, the filter lens cost was estimated to be 1,000 times cheaper than the surgical microscope.

Table 2. Outcome Comparison between Video and Microscope Magnification

| Outcome                  | Video     | Microscope | P     |
|--------------------------|-----------|------------|-------|
| Diameter (mm)            | 0.32±0.13 | 0.37±0.07  | 0.39  |
| Time (m)                 | 15.88±2.09| 15.13±2.98 | 0.59  |
| Skin scar length (mm)    | 1.48±0.29 | 1.58±0.31  | 0.55  |

Note: our magnification tool had no significant difference compared with the surgical microscope.

![Fig. 2. On site video super-microsurgery. The surgeon looked at the monitor to complete anastomosis.](image-url)
CONCLUSIONS

The simple attachment of close-up lens filter on a surgical field camera suspended in the surgical room was effective for pediatric lymphedema LVA. A simple magnification adjustment enabled super-microsurgical anastomosis with various merits such as inexpensive start-up, requiring small head, and a large surgical field provided for surgeon.

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