SUBSPECIALTY PROCEDURES

REPLANTATION OF A COMPLETELY AMPUTATED THUMB WITH ASSISTANCE OF HIGH-SPEED VIDEO RECORDING

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Abstract

Background: Generally, surgeons assess the quality of vascular anastomosis in digit replantation on the basis of their experience.

Description: The steps for replantation of a completely amputated thumb, with assistance of high-speed video recording, consist of (1) debridement, (2) fixation, (3) tendon suture, (4) anastomosis, and (5) wound closure^{1,2}.

Alternatives: Revision amputation or flap coverage.

Rationale: With the assistance of high-speed video recording, the refilling velocity ratio (RVR) is an objective index for the quality assessment of the vascular anastomosis.

Introductory Statement

The refilling velocity ratio (RVR) obtained during the patency test with the assistance of high-speed video recording allows an objective evaluation of anastomosis quality in digit replantation.

Indications & Contraindications

Indications

- Completely amputated digits.
- Incompletely amputated digits.

Contraindications

- Diabetes.
- Peripheral vascular disease.
- Hypercoagulability.
- Tobacco use.
- Heart disease.
- Ischemia time (>12 hours).

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Step-by-Step Description of Procedure (Video 1)

Video 1 Surgical procedure of the replantation of a completely amputated thumb.

Step 1: Debridement

Debride the wounds in the amputated digit.

- Irrigate the wound with saline solution.
- Incise the contaminated and necrotic margin of the skin, tendons, and bones.
- Mark the edge of the severed tendon, both the proximal and the distal portion, with 4-0 nonabsorbable tendon sutures.

Step 2: Fixation

Stabilize the bones with Kirschner wires.

- Shorten the bone appropriately.
 - Consideration of the level and geometry of the amputation is required. It is necessary to reference the recipient site to match the orientation of the bone ends. When shortening the bone in a thumb amputation, the resection should be maximized on the amputated part so that, if the replant fails, thumb length is maintained.
- Reduce the fracture in order to place the bone at a proper position.
- Insert the Kirschner wires in a crossed pattern.
- Confirm the fixation with C-arm fluoroscopic imaging.

Step 3: Tendon Suture

Repair the flexor and extensor tendons.

- Find the cut edge of the flexor tendon using the marked suture.
- Suture the flexor tendon to the proximal stump with Tajima sutures using a 4-0 nonabsorbable suture³. Tie the 2 strands of the repair simultaneously to achieve a symmetric repair.
- Repair the extensor tendon with 2 horizontal mattress sutures using a 4-0 nonabsorbable suture.

Step 4: Anastomosis

Repair vessels and nerves.

- Clean up the proximal and the distal margin of the nerves and vessels.
- Cut off the distorted margin of the nerves and vessels until normal intima is identified.
- Anastomose the vessels under the microscope with 8-0 monofilament nylon sutures. Place the initial sutures 180° apart. The size of each “bite” should be approximately 1 to 2 times the thickness of the arterial wall. The interval of each “bite” (i.e., the distance between the 2 sutures) should be approximately 2 to 3 times the thickness of the arterial wall.
- Align the fascicles and perform an epineurial repair using two or three 9-0 or 10-0 sutures.
- Test the patency of the vascular anastomosis and record simultaneously with a high-speed camera.
 - Record a high-speed video with a camera (Sony RX100 V). For the patency test, empty a vascular segment with the use of 2 microforceps and then remove the occluding forceps and record the refilling of the segment on video. Conduct the patency tests on vascular segments proximal and distal to the anastomosis.
- Analyze the results and calculate the arterial RVR and the sum of venous RVRs.
- Identify the start and end points of refilling by watching the images in consecutive order. Determine the refilling time by the number of frames between the start and end points, with each frame measuring 1/1,000 of a second. Calculate the refilling velocity according to the following formula:

$$\text{refilling velocity} = \frac{\text{empty length}}{\text{refilling time}}$$

Calculate the RVR for arteries according to the following formula:

$$\text{arterial RVR} = \frac{\text{distal refilling velocity}}{\text{proximal refilling velocity}}$$

Calculate the RVR for veins according to the following formula:

$$\text{venous RVR} = \frac{\text{proximal refilling velocity}}{\text{distal refilling velocity}}$$

Perform the patency tests twice to calculate an average RVR.

- Guarantee that the arterial RVR and the sum of venous RVRs are >0.4 and >1.0, respectively. If the results are unsatisfactory, repeat anastomosis is required. If the tension is too high, appropriate vein graft is necessary to repair the gap of the artery.

Step 5: Wound Closure

Close the wound and check the blood supply to the digit.

- Close the wound with interrupted nylon sutures.
- Check the blood supply again by piercing the skin of the distal end of the digit using a 1-mL syringe needle. If the digit keeps bleeding, it is obvious that the anastomosis of the artery is successful.

Results

In a study of replantation of 182 completely amputated digits with the assistance of high-speed video recording, the survival rate of the digits was significantly higher than that of historical controls⁴. After the use of this technique in the present case shown in the video, the arterial RVR and venous RVR sum were ensured to >0.4 and >1.0 , respectively, and the thumb survived. Patients should expect some loss of sensation permanently and possible stiffness of the interphalangeal joint.

Pitfalls & Challenges

- Performing a qualified video recording needs experience and training. It is important to stabilize the camera during shooting.
- The recording lasts for only several seconds. A good coordination between surgeon and photographer is necessary.

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