



Use of digital subtraction angiography for assessment of digital replantation*

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Received July 11, 2011; Revision accepted Nov. 30, 2011; Crosschecked Feb. 17, 2012

Abstract: Objective: To assess the blood flow of the proper digital artery using digital subtraction angiography (DSA) in the early stage after replantation. Methods: From January 2006 to October 2010, 27 anastomosed arteries in 27 replanted digits were included in the study. The patients included nine males and four females. The patients received DSA at 48 to 96 h after digital replantation. Based on DSA image, the blood flow was classified into normal, slow-running, and flow-stopping types. The patients with normal digital blood flow were given continuous routine treatments; the patients with slow-running flow were given the conservative treatments, such as release of the tight dressings, removal of stitches, keeping warm, the use of massage, and the use of anticoagulants and anti-inflammatory drugs; the patients with flow-stopping received immediate surgical re-exploration. Results: In this series, 23 digits in 11 patients showed a normal blood flow, and these digits all survived. In one of 13 patients, two digits which displayed slow-running flow also survived after conservative treatments. In two of 13 patients, two digits showed flow stopping, with one surviving and one failing after re-exploration and arterial revision. Conclusions: The DSA can be used to assess the blood flow of the proper digital artery in the early stage after replantation. It provides essential information for salvaging the replanted finger.

Key words: Digital subtraction angiography, Proper digital artery, Replantation, Blood flow

doi:10.1631/jzus.B1100223

Document code: A

CLC number: R445.4

1 Introduction

Arterial insufficiency is the most common cause for digital replantation failure (Isaacs, 1977; Sturzenegger and Büchler, 1990; Özçelik *et al.*, 2006). The conventional examination of color, temperature, turgor, and recapillarization can be used to confirm the disorder (Cankar *et al.*, 2000). However, these clinical signs usually lag behind the actual situation. In addition, differential diagnosis between the arterial spasm and thrombosis is often difficult in the early stages.

Digital subtraction angiography (DSA) is an

emerging technology that has many characteristics in common with the development of the computed tomography (CT) scanner since the 1970s. DSA is a computer-assisted technique that integrates digital data collection and computer processing to produce a medical image (Harrington *et al.*, 1982). The examination has been used for diagnosis of arterial diseases of the hand (Wallner *et al.*, 1989). Recently, DSA became a gold standard in evaluating arterial diseases and injuries (Han *et al.*, 2011; Miabi *et al.*, 2011; Shahzad and Younas, 2011).

The purpose of this study is to assess digital blood flow using DSA in the early stages after replantation. We hope the DSA imaging can provide essential information that helps the surgeons salvage the digital replantation.

* Project supported by the Zhejiang Provincial Health Department Foundation (No. 2009A088), China
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2 Patients and methods

From January 2006 to October 2010, 16 patients received DSA at a mean time of 76.2 h (range 48–96 h) after surgery. Three patients who developed wound infection were excluded. A total of 27 anastomosed proper digital arteries (PDAs) in 13 patients (nine men and four women; mean age 29 years, range 18–50 years) were included. The mechanism of the injury includes sharp instrument injury ($n=3$), crush injury ($n=7$), and avulsion ($n=3$). All fingers were completely amputated. There were thumb ($n=5$), index ($n=10$), middle ($n=3$), ring ($n=6$), and little ($n=3$) fingers.

The inclusion criteria of the study were a patient receiving single or multiple digital replantation at 48 to 96 h after surgery, a replanted digit with single PDA repair, a negative iodine allergy test, normal heart and kidney functions, and a normal range of clotting time test. The exclusion criteria included a replanted digit which developed wound infection. Those digits associated with venous insufficiency based on clinical findings were excluded because restoring sufficient venous drainage is the top priority before performing arterial revision. Those digits with double PDA repair were also excluded because thrombosis in single PDA may not result in loss of the finger.

We performed DSA using an Allura Xper FD20 system (Philips Inc., Eindhoven, the Netherlands). The patient was placed in a supine position on the

operating table. The injured hand was placed parallel to the patient's body. Under local anesthesia, an artery sheath was firstly placed into the femoral artery on the opposite side. Thereafter, a multiple functional catheter was passed through the artery sheath into the brachial artery on the injured side (Seldinger's techniques). Angiography was performed using the peripheral-hand mode on the anteroposterior, lateral, and oblique views. The bolus rate of contrast medium (iodixanol: iodine 320 mg/ml) was 2.5–3.0 ml/s and bolus volume was 10–12 ml.

The blood flow of the PDA was assessed on DSA image by three senior interventional radiologists. The blood flow was classified into normal, slow-running, and flow-stopping types. The patient with normal digital blood flow received continuous routine treatments. The patient with slow-running flow was given additional conservative treatments including release of the tight dressings, removal of several stitches, keeping warm, the use of massage, and the use of anticoagulants and anti-inflammatory drugs. The patient with flow-stopping received immediate surgical re-exploration. At 15 d after replantation, the surviving digit displayed warmth, pink color, and a normal capillary refilling.

3 Results

Patients' demographics, surgical and DSA details, managements, and outcomes are shown in Table 1.

Table 1 Patients' demographics, surgical and DSA details, managements, and outcomes

Case	Sex	Age (year)	Side	Cause	Replanted finger	Repaired PDA	RSDAI (h)	Blood flow on DSA	Management	Result
1	M	22	R	Crush	Thumb, index	UI, UI	3	Normal	Routine	Survival
2	M	19	L	Crush	Index, ring	Ra, Ra	18	Normal	Routine	Survival
3	M	23	R	Sharp	Middle, index	UI, UI	20	Normal	Routine	Survival
4	M	43	R	Crush	Ring	UI	4	Flow-stopping	Arterial revision	Survival
5	F	32	L	Sharp	Thumb, middle, index	Ra, Ra, Ra	8	Normal	Routine	Survival
6	M	30	R	Avulsion	Index, ring, little	UI, UI, UI	10	Normal	Routine	Survival
7	M	18	R	Avulsion	Middle, ring	Ra, Ra	15	Flow-stopping, normal	Arterial revision, routine	Failure, survival
8	F	50	L	Crush	Index	Ra	12	Normal	Routine	Survival
9	M	30	L	Crush	Thumb, index	UI, UI	13	Normal	Routine	Survival
10	F	20	L	Sharp	Index, little, ring	UI, UI, UI	17	Normal	Routine	Survival
11	M	38	L	Crush	Ring, little	Ra, Ra	8	Slow-running	Conservative treatments	Survival
12	F	28	R	Avulsion	Index, thumb	Ra, Ra	5	Normal	Routine	Survival
13	M	24	R	Crush	Thumb, index	UI, UI	3	Normal	Routine	Survival

R: right; L: left; UI: ulnar; Ra: radial; RSDAI: replantation surgery delay after injury; DSA: digital subtraction angiography; PDA: proper digital artery

In this series, 23 anastomosed PDAs in 23 digits showed normal blood flow (Fig. 1a). All these digits survived. Two PDAs in two patients showed flow-stopping (Figs. 1b and 1c; cases 4 and 7 in Table 1), which required immediate re-exploration and revision. Two patients refused receiving a repeated DSA examination because they could not afford the fees.

In one of the two patients, his right middle finger was lost (case 7 in Table 1). In one patient (case 11 in Table 1), two PDAs in the left ring and little fingers showed slow-running blood flow (Fig. 1d). The fingers survived after conservative treatments.

In this series, the complications related to the procedure of DSA such as hematoma were not observed.

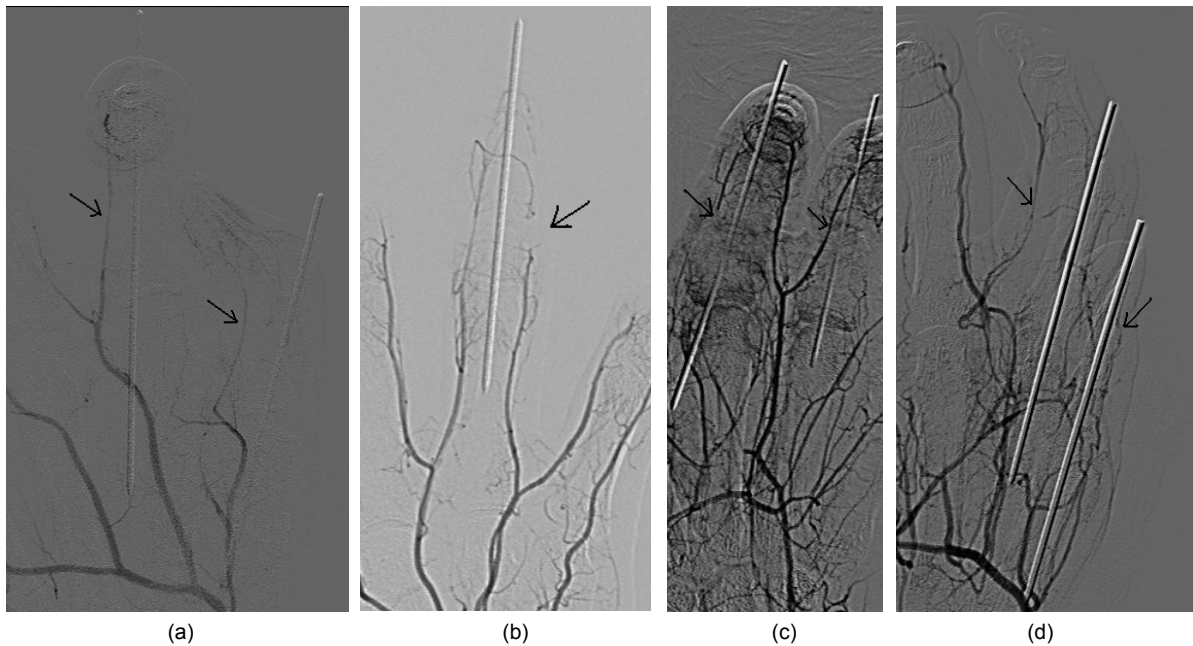


Fig. 1 Digital subtraction angiography (DSA) images of anastomosed proper digital arteries (PDAs) in four subjects (a) A 22-year-old male underwent digital replantation in his right thumb and index fingers. The image shows a normal blood flow in the digital arteries at 48 h after replantation (arrows). The digits were survived. (b) A 43-year-old male underwent digital replantation in his right ring finger. The image shows blood flow-stopping flow in the digital artery at 80 h after replantation (arrow). A thrombosis about 1 cm in length was found at re-exploration. The digit survived after revision. (c) An 18-year-old male received digital replantation in his right middle and ring fingers. The image shows stopping blood flow in the digital artery of the middle finger (left arrow) and normal blood flow of the ring finger (right arrow) at 62 h after replantation. A thrombosis was found at the anastomosis site of the middle finger at re-exploration. The middle finger is lost and the ring finger survived. (d) A 38-year-old male underwent digital replantation in his left ring and little fingers. The image shows slow-running blood flow in the digital arteries at 50 h after replantation (arrows). The two fingers survived after conservative treatments

4 Discussion

PDA spasm and thrombosis are common after digital replantation. The incidence rate of the complications was reported as high as 50%–70% in the initial 48–92 h (Cheng G.L. *et al.*, 1991; Cheng H. *et al.*, 1999; Lu *et al.*, 2008; Zhang *et al.*, 2008). During the period, the contractile function of the arterial muscle recovers immediately after re-attachment, while the relaxing action is still absent. An increased arterial contraction can be triggered by cold temperature, pain, smoking, and even a sudden change of

body position, etc. A state of long lasting vasospasm can result in thrombosis that is the main cause of replantation failure. Therefore, early detection of the abnormalities is critical for a successful replantation (Cheng G.L. *et al.*, 1991). If not managed in a timely way, vascular crisis might result in loss of a replanted finger. Therefore, it is important for the surgeons to judge vascular crisis or abnormality of blood flow of a replanted finger and to predict its early stage survival.

Capillary refill time can reflect perfusion of the replanted digit (Pickard *et al.*, 2011), but it is indirect for assessment of arterial blood flow. Walaszek and

Zyluk (2008) assessed the blood flow of the anastomosed arteries using Doppler ultrasound after digital replantation. However, imaging was interfered with by the Kirschner wire. CT angiography was also limited due to interference of internal fixator (Machetanz *et al.*, 2001; Klein-Weigel *et al.*, 2007; Walaszek and Zyluk, 2008).

According to our experience, DSA should be performed in the early stages after finger replantation. In our series, those digits with normal blood flow image survived uneventfully without the presence of clinical signs of arterial insufficiency. Four of 27 replanted digits with normal clinical signs displayed slow-running or flow-stopping blood flow on DSA images, which revealed that the clinical findings can lag behind the angiography. Three of four digits survived after immediate conservative therapies or surgical intervention.

Whilst performing DSA, insertion of the wire and catheter should be gently manipulated to avoid possible vessel damage and vasospasm. The advantage of DSA is to find arterial insufficiency of a replanted digit in the early postoperative stage. DSA has disadvantages. The examination is invasive and expensive. The use of contrast media has risks of cardiac and renal impairments. In addition, injection of contrast media at a place far away from the replanted finger, such as the brachial artery, can decrease the risk of vasospasm. In our series, complications related to the procedure were not noted.

This study has limitations. The sample size is small and the study ideally should be prospective, randomized, and blinded. In addition, assessment of the blood flow is subjective because it is solely based on visual inspection.

References

- Cankar, K., Arnež, Z.M., Finderle, Z., Štrucl, M., 2000. Microvascular skin response to local cooling and body tilt early after digital replantation. *J. Hand Surg. Am.*, **25**(3): 552-558. [doi:10.1053/jhsu.2000.6003]
- Cheng, G.L., Pan, D.D., Qu, Z.Y., Lin, B., Yang, Z.X., Fang, G.R., Gong, X.S., Tang, H.P., 1991. Digital replantation: a ten-year retrospective study. *Chin. Med. J. (Engl.)*, **104**(2):96-102.
- Cheng, H., Zhang, W.W., Li, X.Y., 1999. Management of arterial crisis after finger replantation. *Chin. J. Hand Surg.*, **15**(3):238-239.
- Han, A., Yoon, D.Y., Chang, S.K., Lim, K.J., Cho, B.M., Shin, Y.C., Kim, S.S., Kim, K.H., 2011. Accuracy of CT angiography in the assessment of the circle of Willis: comparison of volume-rendered images and digital subtraction angiography. *Acta Radiol.*, **52**(8):889-893. [doi:10.1258/ar.2011.110223]
- Harrington, D.P., Boxt, L.M., Murray, P.D., 1982. Digital subtraction angiography: overview of technical principles. *AJR Am. J. Roentgenol.*, **139**(4):781-786.
- Isaacs, I.J., 1977. The vascular complications of digital replantation. *Aust. N. Z. J. Surg.*, **47**(3):292-299. [doi:10.1111/j.1445-2197.1977.tb04292.x]
- Klein-Weigel, P., Pavelka, M., Dabernig, J., Rein, P., Kronenberg, F., Fraedrich, G., Piza-Katzer, H., 2007. Macro- and microcirculatory assessment of cold sensitivity after traumatic finger amputation and microsurgical replantation. *Arch. Orthop. Trauma Surg.*, **127**(5): 355-360. [doi:10.1007/s00402-007-0287-x]
- Lu, W., Wang, D., Liu, L., Xiong, J., He, Q., 2008. Nail fold capillary observation in replanted severed fingers. *Microsurgery*, **28**(1):13-16. [doi:10.1002/micr.20445]
- Machetanz, J., Rörich, S., Gress, S., Schaff, J., Bischoff, C., 2001. Evaluation of clinical, electrophysiologic, and computed tomographic parameters in replanted hands. *Arch. Phys. Med. Rehabil.*, **82**(3):353-359. [doi:10.1053/apmr.2001.19741]
- Miabi, Z., Pourfathi, H., Midia, M., Midia, R., Parvizi, R., 2011. Comparison of CT angiography and digital subtraction angiography in the diagnosis of aortic coarctation. *Pak. J. Biol. Sci.*, **14**(1):74-77. [doi:10.3923/pjbs.2011.74.77]
- Ozçelik, I.B., Purisa, H., Sezer, I., Mersa, B., Aydin, A., 2006. The results of digital replantations at the level of the distal interphalangeal joint and the distal phalanx. *Acta Orthop. Traumatol. Turc.*, **40**(1):62-66.
- Pickard, A., Karlen, W., Ansermino, J.M., 2011. Capillary refill time: is it still a useful clinical sign? *Anesth. Analg.*, **113**(1):120-123. [doi:10.1213/ANE.0b013e31821569f9]
- Shahzad, R., Younas, F., 2011. Detection and characterization of intracranial aneurysms: magnetic resonance angiography versus digital subtraction angiography. *J. Coll. Physicians Surg. Pak.*, **21**(6):325-329.
- Sturzenegger, M., Büchler, U., 1990. Acute vascular disorder as a complication of replantation and revascularization of the digital area. *Handchir. Mikrochir. Plast. Chir.*, **22**(1): 39-45.
- Walaszek, I., Zyluk, A., 2008. Long term follow-up after finger replantation. *J. Hand Surg. (Eur. Vol.)*, **33**(1): 59-64. [doi:10.1177/1753193407088499]
- Wallner, B., Kratzsch, G., Friedrich, J.M., Roth, J., 1989. Intra-arterial DSA of the hand arteries in the diagnosis of inflammatory connective tissue diseases. *Rofö*, **15**: 565-568 (in German). [doi:10.1055/s-2008-1047241]
- Zhang, X., Wen, S., Wang, B., Wang, Q., Li, C., Zhu, H., 2008. Reconstruction of circulation in the fingertip without vein repair in zone I replantation. *J. Hand Surg. Am.*, **33**(9): 1597-1601. [doi:10.1016/j.jhsa.2008.05.005]