Application of relay puncture technique in treating patients with complicated lower extremity arterial diseases

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Objective: This study aimed to introduce and evaluate the safety and efficacy of the relay puncture technique in patients with complicated lower extremity arterial diseases.

Methods: A total of 21 patients (16 male and five female patients; median age: 70 years old), who had suffered from lower extremity arterial diseases between December 2014 and July 2017, were retrospectively collected. For all patients, the contralateral femoral artery was not available for puncture access, and the length of the devices was too short for the brachial artery approach. Therefore, the relay puncture technique, in which the first puncture was performed on the brachial artery, followed by an anterograde puncture on the femoral artery, was used to accomplish the endovascular therapy. Percutaneous transluminal angioplasty (PTA) and/or percutaneous transluminal stenting (PTS) was usedto assess the efficacy of the relay puncture technique. The ankle - brachial index (ABI) and Rutherford Clinical Classification (RCC) were used to evaluate the improvement of symptoms after treatment . Patients were followed up for 1, 3, 6 and 12 months, and annually (mean: 16.6 months) after discharge.

Results: The relay puncture treatment had a 100% technical success rate, and immediately decreased the ischemic symptoms of patients after the procedure. The ABI significantly increased from 0.33 ± 0.18 to 0.75 ± 0.21 at the 1-year follow-up time point ($P < 0.05$). No serious complications occurred during the follow-up period.

The 1-year primary patency rate was 71.43%.

Conclusion : The relay puncture technique is a feasible technique in the hands of experienced and skilled equipment operators for the treatment of lower extremity arterial diseases, when the contralateral femoral artery is not available for puncture, and the length of the device is too short to treat the distal lesion of the femoral artery and popliteal artery through the brachial artery approach.

1 **Application of relay puncture technique in treating patients with complicated**

2 **lower extremity arterial diseases**

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52 **Abstract**

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54 puncture technique in patients with complicated lower extremity arterial diseases.

55 **Methods:** A total of 21 patients (16 male and five female patients; median age: 70 years old),

56 who suffered from lower extremity arterial diseases between December 2014 and July 2017,

57 were retrospectively collected. For all patients, the contralateral femoral artery was not available

58 for puncture access, and the length of the devices was too short for the brachial artery approach.

59 Therefore, the relay puncture technique, in which the first puncture was performed on the

60 brachial artery, followed by an anterograde puncture on the femoral artery, was used to

61 accomplish the endovascular therapy. Percutaneous transluminal angioplasty (PTA) and/or

62 percutaneous transluminal stenting (PTS) was used to assess the efficacy of the relay puncture

63 technique. The ankle-brachial index (ABI) and Rutherford Clinical Classification (RCC) were

64 used to evaluate the improvement of symptoms after treatment. Patients were followed up for 1,

65 3, 6 and 12 months, and annually (mean: 16.6 months) after discharge.

66 **Results:** The relay puncture treatment had a 100% technical success rate, and immediately

67 decreased the ischemic symptoms of patients after the procedure. The ABI significantly

68 increased from 0.33 ± 0.18 to 0.75 ± 0.21 at the 1-year follow-up time point ($P<0.05$). No

69 serious complications occurred during the follow-up period. The 1-year primary patency rate was

70   71.43%.

71   **Conclusion**: The relay puncture technique is a feasible technique in the hands of experienced

72   and skilled equipment operators for the treatment of lower extremity arterial diseases, when the

73   contralateral femoral artery is not available for puncture, and the length of the device is too short

74   to treat the distal lesion of the femoral artery and popliteal artery through the brachial artery

75   approach.

76   **Keywords:** Antegrade femoral artery puncture, lower extremity arterial disease, endovascular

77   treatment

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79   **1. Introduction**

80   Advances in endovascular technologies in recent years have offered more options for

81   patients with lower extremity arterial diseases and expanded the indications for endovascular

82   therapy [1]. However, in some complex situations when the contralateral femoral artery cannot

83   be punctured, such as when cover stents are implanted on the entire contralateral femoral artery,

84   or the length of the device is too short to treat the distal end of the femoral and popliteal artery

85   through the brachial artery approach, a simple endovascular technique cannot solve the problem

86   [2]. For these situations, a hybrid procedure, such as endovascular and open surgery, is usually

87   an appropriate choice [3]. However, some disadvantages of the hybrid procedure include more

88   complicated surgery requiring skilled clinicians to achieve appreciable outcomes, and the

89   requirement of an operating room for performing this procedure [4]. Therefore, it is imperative to

90   determine new techniques that can replace hybrid surgery with acceptable efficacy, safety and

91   simplicity in the treatment of complicated lower extremity diseases.

92   In the present study, a simple novel endovascular technique, which was named, the relay

93   puncture technique, was employed, in which the first puncture was performed on the brachial

94   artery, followed by an anterograde puncture of the femoral artery. The investigators were able to

95   treat the femoral artery lesions through the brachial artery, while the investigators were able to

96   treat lesions distal to the popliteal artery through the femoral artery. The relay puncture

97   technique was used to treat patients whose contralateral access was not available, since these

98   patients had ipsilateral or contralateral iliac and common femoral axis stenosis or occlusions, a

99   very angulated aortic bifurcation of the iliac, a puncture site with heavy calcifications or a stent,

100   infection of the groin, and a cross-over maneuver in the setting of the bifurcated aortic graft or

101   pre-existing iliac kissing stents. The safety and efficacy of the relay puncture technique was

102   evaluated in the present study.

103

104   **2. Materials and Methods**

105   *2.1. Eligibility*

106   A total of 21 patients (16 male and five female patients), who were within 48-81 years old

107   (median age: 68.5 years old) and suffered from lower extremity arterial disease, were collected in

108   our hospital between December 2014 and July 2017. The diagnosis of each patient was

109   confirmed by ultrasonography and computed tomography angiography (CTA) before the

110   treatment. All patients had clinical symptoms of critical chronic lower extremity ischemia. The

111   ankle brachial index (ABI) and Rutherford Clinical Classification (RCC) before and after the

112   operation were used to evaluate the improvement of the lower extremity ischemia of each patient

113   after the procedure. According to the TASC classification, all patients in the present study were

114   type D, and all patients declined to have open surgery, which was probably due to fear of major

115   trauma, advanced age, and/or their family's wishes.

116 *2.2. Institutional review*

117   The experimental protocol of the present study complied with the principles outlined in the

118 Declaration of Helsinki, and was approved by the Ethics Committee of our institution. All

119 subjects provided a signed informed consent.

120 *2.3 Procedures of the relay puncture technique*

121   The patient was placed in the supine position and hypodermically administered with heparin

122 (5,000 units) after a 5-French sheath (Terumo, Japan or Cook, USA) was inserted through the

123 left brachial artery, followed by repeated heparin administration in prolonged procedures. After

124 endovascular treatment of the iliac, femoral, or popliteal artery, the 5F sheath was changed to a

125 6F sheath, which is a 90-cm-long armored introducer sheath (COOK, USA), in order to achieve

126 adequate support and strengthen the control of the catheter. Then, a 0.035-inch J-type guidewire

127 (Terumo, Japan) or 0.018-inch guidewire (V18; Boston Scientific, USA) supported by a 5F

128 vertebral artery angiography catheter (Cordis, Johnson & Johnson, USA) was navigated in the

129 proximal common femoral artery.

130   In the present study, the relay puncture technique was used on the ipsilateral femoral artery

131 in the following situations: the contralateral femoral artery could not be punctured (the stents

132 were implanted in the entire contralateral femoral artery in seven patients); the stents were

133 implanted into the aortic artery in the iliac lesion (four patients); there was abdominal aortic

134 aneurysm after the endovascular repair (five patients), which made it difficult for the devices to

135 cross over the bifurcation; the amputation of the contralateral leg did not allow the on-site

136 puncture of the femoral artery (five patients). These five patients only required the recanalization

137 of the contralateral lower extremity artery due to cost problems, and the length of the devices

138 was too short to treat the distal end of the femoral artery and popliteal artery through the brachial

139   artery approach. The lesions in all these patients involved the area of the upper inguinal, through

140   which an antegrade femoral puncture could not be successfully performed.

141   The detailed procedures of the puncture technique are described, as follows. After the

142   recanalization of the proximal part of the femoral artery, the wire was left in place as a marker.

143   Then, an antegrade puncture was performed at the groin under fluoroscopic guidance, and a 5F

144   10-cm sheath was inserted. Then, another J-type 0.035-inch guide wire or V18 was used to cross

145   the femoropopliteal lesion, including the tibial disease, followed by a 6-8 mm diameter classical

146   percutaneous transluminal angioplasty (PTA) balloon (Inpact, Medtronic, Minneapolis, MN,

147   USA) in the iliofemoral segment, a 5-6 mm diameter balloon in the femoropopliteal, and a 2-3

148   mm diameter balloon in arteries below the knee, and stenting. The balloon inflation times varied

149   within 60-300 seconds at nominal pressure. Subintimal angioplasty was also used, and

150   subintimal arterial flossing with the antegrade-retrograde intervention (SAFARI) technique was

151   used for re-entry. Immediately after the vascularization procedure, the sheath was removed from

152   the femoral artery, and a 6-French vascular closer (Exoseal, Cordis; Johnson & Johnson, USA)

153   was used to stop the bleeding of the punctured site. The median compression time was five

154   minutes (range: 3-10 minutes). The angioplasty inside the punctured site with a 6-mm balloon

155   was helpful in stopping the bleeding after the sheath was removed (6/16). Finally, PTA and

156   percutaneous transluminal stenting (PTS) were performed on the proximal part of the femoral

157   artery and iliac artery through the left brachial artery approach without any open surgery. After

158   the completion of all these procedures, the sheath in the left brachial artery was withdrawn. All

159   the above-mentioned endovascular procedures were performed by experienced interventional

160   radiologists in our center.

161   *2.4 Endpoints and follow up*

162   The primary endpoint was the efficacy of the relay puncture technique, as indicated by the

163   acute technical success and post-procedure clinical improvement of critical limb ischemia (CLI)

164   symptoms. The secondary endpoint was the safety of this technique, as indicated by the number

165   or severity of complications associated with this procedure.

166   Color Doppler ultrasonography and/or CT angiography were performed at 1, 3, 6 and 12 months,

167   and annually, or when symptoms recurred after discharge. Antiplatelet therapy was administered

168   during the whole life of each patient after treatment to prevent restenosis.

169   *2.5. Statistical analysis*

170   Data were presented as mean ± standard deviation. All statistical analyses were performed

171   using SPSS software version 22.0 for PC (SPSS Inc., Chicago, IL, USA). Least significant

172   difference *t*-test was used to compare the ABI before and after treatment. A *P*-value <0.05 was

173   considered statistically significant.

174

175   **3. Results**

176   *3.1. Short term outcomes*

177   A total of 21 patients (16 male and five female patients; median age: 70 years old), who

178   suffered from lower extremity arterial diseases from December 2014 to July 2017, were

179   retrospectively collected. All patients were diagnosed with lower extremity arterial disease

180   before treatment. Preoperative CTA clearly revealed the occlusive lesions of the lower extremity

181   arteries (Figs. 1 and 2). For all these patients, the contralateral femoral artery was not available

182   for puncture access, and the length of the devices was too short for the brachial artery approach.

183   Among these patients, seven patients had cover stents on the entire contralateral femoral artery,

184   four patients had kissing stents in the aortoiliac lesion, five patients experienced endovascular

185 repair of abdominal aortic aneurysm, and five patients underwent amputation of the contralateral

186 leg due to ischemia. After a detailed preoperative discussion and project design, all patients

187 underwent the relay puncture procedure, and technical success was achieved in all occlusive

188 arteries (Figs. 3 and 4). Furthermore, no complication occurred during the treatment. A total of

189 87 stents (median: 3) were implanted in 21 patients. Perioperative complications included

190 hematoma (one patient) at the brachial artery puncture site and heart failure (one patient) before

191 discharge. These two patients were successfully treated and discharged after treatment. Moreover,

192 the postoperative ABI significantly increased (0.33 ± 0.18 *vs.* 0.75 ± 0.21, *P*<0.05).

193 Correspondingly, the ischemia symptoms were immediately alleviated after the treatment, as

194 evaluated by RCC (Table 1).

195 *3.2. Long-term outcomes*

196 All patients were followed up for 4-28 months (mean: 16.6 months). During the follow-up

197 period, no serious complications were observed. Color Doppler ultrasonography revealed that the

198 1-year primary patency rate was 71.43% (15/21). The changes in ABI of these patients during

199 the follow up period are summarized in Table 1.

200

201 **4. Discussion**

202 Since the SAFARI technique was invented in clinic, an increasing number of patients who

203 suffered from lower extremity arterial disease have been successfully treated with endovascular

204 repair [5]. The SAFARI technique has also broadened the indications for endovascular therapy in

205 patients with lower extremity arterial disease. However, in some complex situations, lesions

206 could not be merely cured by endovascular treatment, even with the SAFARI technique. The

207 patients presented in the present study had a complicated pathophysiology in diseased lower

208   extremities, and this could not be treated by merely traditional endovascular methods. Therefore,

209   the two position's puncture method was applied to complete the endovascular treatment for these

210   patients. The investigators named this method the relay puncture technique. The present study

211   suggests that the relay puncture technique has appreciable safety and efficacy.

212   *4.1 Relay puncture technique*

213   Patients in the present study did not have access on the contralateral femoral artery due to

214   different reasons. The hybrid operation, which is a combined endovascular and surgical

215   technique, was used as an alternative to laparotomy to correct inflow lesions in patients with

216   multilevel arterial diseases [6], and this has achieved appreciable patency rates and technical

217   success rates [7]. However, the hybrid surgery exhibited several disadvantages, including the

218   requirement of highly skilled surgeons (there are limited numbers of vascular surgeons), the need

219   for an operation room (the cost of a hybrid operation room is high and cannot be sufficiently

220   provided), and the potentially increased risk of complications and longer recovery period

221   (including the risk correlated to further anesthesia) [8]. For example, one recent meta-analysis

222   that compared the outcomes of the endovascular and open bypass treatment for TASC C-D

223   aortoiliac occlusive disease reported more complications and greater 30-day mortality with open

224   bypass [9].

225   In the present study, the relay puncture technique, which is a new puncture method with

226   different approaches, was proposed to handle these complex vascular lesions. The word "relay"

227   was used in this technique, because the antegrade puncture on the femoral artery after the

228   brachial artery puncture was just like a relay race. This technique has been applied in 21 patients,

229   and the short- and long- term outcomes appeared to be satisfactory, as evidenced by the findings

230   that the technical success rate was 100%, and that the primary long-term patency was 71.43%,

231 which were similar to those previously reported in studies on patients after endovascular

232 treatment [10].

233   For patients in the present study, there was no puncture site available on the lower extremity

234 arteries. Thus, the investigators opted to puncture the left brachial artery first. However, all

235 endovascular devices failed to reach the lesions at the distal part of the femoral and popliteal

236 artery. The SAFARI technique should be able to establish a guidewire line through the whole

237 lesion. However, the size of both the stent delivery catheter and balloon catheter were too big to

238 be pulled into the arteries below the knee. This was the same with the atherectomy catheter and

239 drug-coated balloon. Therefore, the SAFARI technique could not solve the problem of these

240 patients in the present study, who had long lesions that involved the popliteal artery, or even

241 those below the knee. Directly puncturing the stents on the contralateral femoral artery should

242 have been a solution. However, that technology is not mature yet, and few studies have reported

243 good long-term outcomes [12]. Hence, directly puncturing the contralateral femoral artery

244 appeared as the only option [13]. Another approach that might solve the above-mentioned issue

245 for these patients was to insert a large sheath with a drug coated balloon or debulking devices

246 through the stent. This approach may damage the stent structure, subsequently accelerating the

247 occurrence of stent rupture and/or restenosis within the stent. In addition, this technique cannot

248 be used for patients with cover stents. Furthermore, in some cases, stents were implanted into the

249 aortic artery in some aortic-iliac lesions, and it was difficult for the devices to cross over the iliac

250 branches. Most importantly, all patients in the present study had lesions that involved the area of

251 the upper inguinal, which could not be directly antegrade punctured through the femoral artery.

252 Based on the above-mentioned analysis, the investigators decided to use the new relay puncture

253 technique.

254   *4.1.1 Puncture of the brachial artery.*

255   The antegrade approach using the trans-brachial access with long sheaths and dedicated

256   catheters appeared to be the choice for aortoiliac occlusions with or without extension to the

257   femoral-popliteal arterials. This approach offers better push ability, allows access to both iliac

258   arteries, and enables the reentry at the femoral artery to be managed more easily and safely,

259   when compared with the retrograde approach [14]. Although this involved some risks and

260   technical challenges, the investigators continued to choose this approach for patients in the

261   present study, because they had no other puncture channels. It turned out that this antegrade

262   approach was successfully performed in the present study.

263   *4.1.2 Antegrade puncture of the superficial femoral artery*

264   At present, performing an antegrade puncture has become a routine in endovascular

265   treatment for patients suffering from infra-inguinal lower extremity arterial disease [15]. Recent

266   studies have shown that antegrade access *via* the superficial femoral artery (SFA) has practical

267   advantage over classical access *via* the common femoral artery (CFA), in terms of shorter access

268   time, quicker fluoroscopy time, and higher success rate [16; 17]. In the present study, before the

269   SFA was punctured, the guidewire recanalized the vessel and reached the target. Therefore,

270   under fluoroscopy, the antegrade procedure to puncture the guidewire was safe with fewer

271   complications. However, the number of attempts of reentry procedures with the guidewire should

272   be limited to avoid extending the dissection. Regardless of whether it was successful or not, the

273   guidewire guided the antegrade puncture performed to the SFA. In addition, this approach should

274   be performed at the same axis, while the former guidewire should be performed in the lumen, in

275   order to allow these two guide wires to link together. Basically, the first wire created an access,

276   while the second wire took over the treatment of femoral-popliteal lesions, as well as arterial

277 lesions below the knee. The relay approach not only recanalized these infra-inguinal diseases,

278 but also overcame the short-shaft, further increasing the pushing ability and maneuverability of

279 the wire, and the probability of reentry, especially near the popliteal artery. Moreover, the latter

280 wire may be used to reconstruct the arterials below the knee.

281 *4.3 Application of puncture closure devices*

282   Endovascular treatment has been shown to be associated with several complications. For

283 instance, the incidence of hematoma can reach up to 6% for patients undergoing brachial

284 puncture [18], and the incidence of complications following the antegrade puncture of SFA can

285 reach up to 9% [19]. However, the use of closure devices exhibited a significant tendency to

286 decrease these complications [20]. Consistent with these reports, in the present study, the median

287 compression time was only five minutes (3-10 minutes), even in the presence of heparin, which

288 was shorter than the traditional compression time for hemostasis. Furthermore, using the Exoseal

289 device to close the antegrade puncture hole on the femoral artery, endovascular therapy could be

290 quickly continued without bleeding in the present study. A variety of arterial closure devices

291 have been introduced with the aim of reducing bleeding risk. However, all were indicated for

292 femoral use only [21]. In the present study, Exoseal was used for brachial artery puncture site

293 closure, which is a safe technique with an acceptable rate of complications (6%). Thus, no

294 clinical intervention was required.

295

296 **5. Limitations of the present study**

297   The present study was a retrospective study with a limited sample size. Hence, the present

298 findings need to be further corroborated in large cohort studies in the future. In addition, the

299 procedures for the relay puncture technique remains complex, and needs to be performed by an

300 experienced doctor.

301

302

6. Conclusion

304   The present study described the modalities of the "relay puncture" technique. The

305 preliminary results of the present study revealed that this may be a feasible technique in the

306 hands of experienced and skilled operators for the treatment of patients with lower extremity

307 arterial diseases, when the contralateral femoral artery cannot be punctured and the length of the

308 devices is too short to treat the distal lesion of the femoral and popliteal artery through the

309 brachial artery approach.

310

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313

Conflict of interests

315 The authors declare that there is no conflict of interest.

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383 **Figure legends**

384 **Figure 1 The CTA image for patient 1 before the operation.** This image shows that the right

385 SFA was totally occluded, and cover stents were implanted in the entire left CIA to SFA, which

386 was unobstructed. The left femoral artery could not be punctured due to the cover stents.

387

388 **Figure 2 CTA image for patient 2 before the operation.** The image shows that the left SFA

389 was totally occluded. The right leg had a high position amputation one year ago, and the right

390 iliac artery was also occluded. The right femoral artery could not be punctured due to the

391 amputation, and the patient only required recanalization due to economic issues.

392

393 **Figure 3 Images showing the technical steps of the relay puncture technique performed for**

394 **patient 1.** (a-c) Images of the angiography before treatment show the occlusion of the right SFA

395 and the cover stents of the left side. (d, e) The images show that the recanalization was

396 performed to the proximal part of right SFA through the left brachial access, and the PTA was

397 first performed. (f, g) The images show that the relay puncture technique (antegrade puncture)

398 was performed to the right femoral artery under fluoroscopy and the guidance of the guidewire,

399 which was just recanalized. (h, i) The images show that the recanalization was further performed

400 to the distal part of the right SFA and the arteries below the knee after the relay puncture. (j-l)

401   The images show the angiography after endovascular treatment and the removal of the sheath in

402   the right femoral artery. Note that the recanalization was successful without contrast medium

403   overflow.

404

405   **Figure 4 The images show the relay puncture technique used for patient 2.** (a-d) The

406   angiography before treatment shows the occlusion of the left SFA and right iliac to the femoral

407   artery, and that the right femoral artery could not be punctured due to the amputation. (e-h)

408   Similar to Figure 3, the angiography shows that the left SFA was successfully recanalized after

409   the application of the relay puncture technique.

Figure 1

The CTA image for patient 1 before the operation

This image shows that the right SFA was totally occluded, and cover stents were implanted in the entire left CIA to SFA, which was unobstructed. The left femoral artery could not be punctured due to cover stents.

Note: Auto Gamma Correction was used for the image. This only affects the reviewing manuscript. See original source image if needed for review.

Figure 2

CTA image for patient 2 before the operation

The image shows that the left SFA was totally occluded. The right leg had a high position amputation one year ago, and the right iliac artery was also occluded. The right femoral artery could not be punctured due to the amputation, and the patient only required recanalization due to economic issues.

Note: Auto Gamma Correction was used for the image. This only affects the reviewing manuscript. See original source image if needed for review.

Figure 3

Images showing the technical steps of the relaypuncture technique performed for patient 1

(a-c) Images of the angiography before treatment show the occlusion of the right SFA and the cover stents of the left side. (d,e) The images show that the recanalization was performed to the proximal part of right SFA through the left brachial access, and the PTA was first performed. (f,g) The images show that the relay puncture technique (antegrade puncture) was performed to the right femoral artery under fluoroscopy and the guidance of the guide wire, which was just recanalized. (h,i) The images show that the recanalization was further performed to the distal part of the right SFA and the arteries below the knee after the relay puncture. (j-l) The images show the angiography after endovascular treatment and the removal of the sheath in the right femoral artery. Note that the recanalization was successful without contrast medium overflow.

Note: Auto Gamma Correction was used for the image. This only affects the reviewing manuscript. See original source image if needed for review.

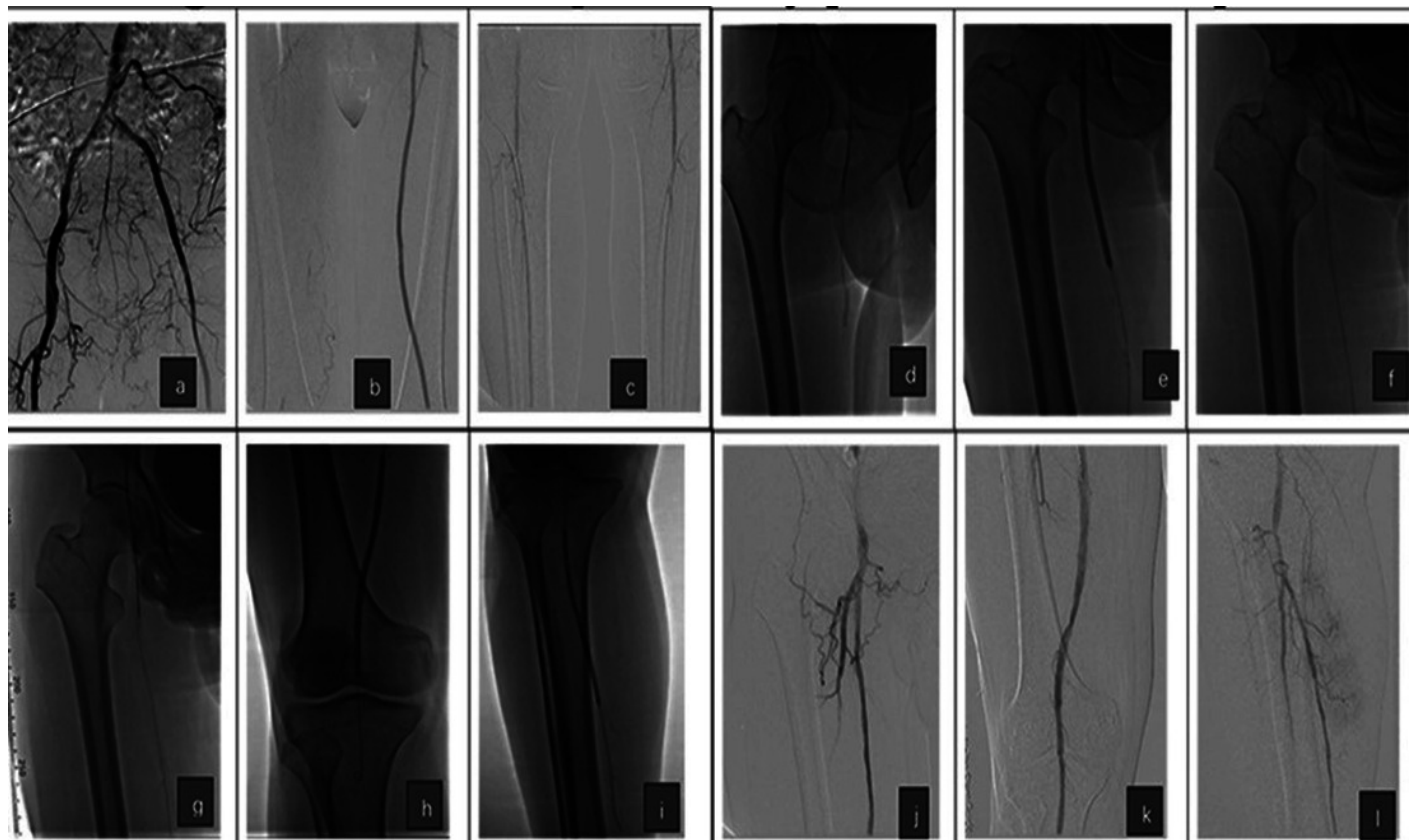



Figure 4

The images show the relaypuncture technique used for patient 2

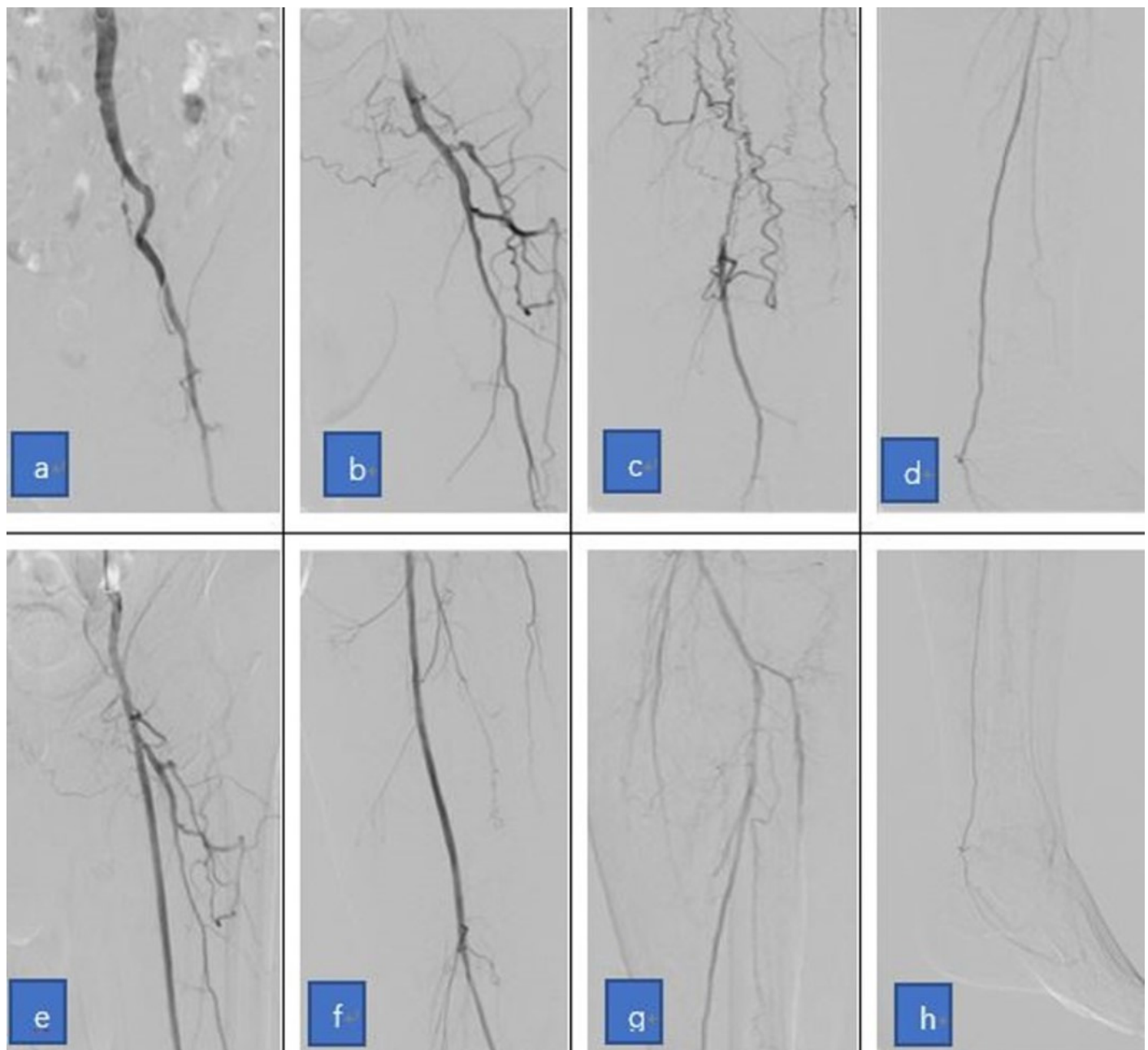
(a-d) The angiography before treatment shows the occlusion of the left SFA and the right iliac to the femoral artery, and that the right femoral artery could not be punctured due to the amputation. (e-h) Similar to Figure 3, the angiography shows that the left SFA was successfully recanalized after the application of the relay puncture technique.

Clinical symptom improvements of patients withinone year in the present study

Table 1. Clinical symptom improvements of patients within one year in the present study

Patient number	Before treatment		Immediately after treatment		3 months after treatment		6 months after treatment		12 months after treatment	
	RCC	ABI	RCC	ABI	RCC	ABI	RCC	ABI	RCC	ABI
1	6	0	0	0.55	0	0.63	1	0.58	4	0.42
2	4	0.51	0	0.81	0	0.79	0	0.83	0	0.65
3	4	0.48	0	0.93	0	0.90	0	0.88	0	0.92
4	5	0.22	0	0.68	0	0.71	0	0.68	0	0.77
5	4	0.36	0	0.99	0	1.03	0	0.98	0	0.95
6	6	0	1	0.70	1	0.82	1	0.79	4	0.58
7	3	0.60	0	1.08	0	1.05	0	1.02	0	0.98
8	4	0.41	0	0.93	0	0.93	0	0.88	0	0.80
9	5	0.45	0	1.12	1	1.05	0	1.02	0	0.95
10	5	0.36	0	0.81	0	0.88	0	0.90	0	0.89
11	4	0.72	0	1.10	0	1.00	0	0.98	0	0.96
12	6	0	1	0.69	1	0.73	1	0.63	5	0.36
13	4	0.58	0	1.03	0	1.05	0	0.95	0	0.90
14	4	0.35	0	0.95	0	0.99	0	0.86	0	0.79
15	5	0.33	0	0.88	0	0.80	0	0.79	0	0.66
16	6	0.22	0	0.93	0	0.99	0	0.85	4	0.45
17	5	0.17	0	0.99	0	0.97	0	0.91	1	0.86
18	4	0.32	0	1.02	0	1.00	0	0.89	0	0.92
19	6	0	1	0.76	1	0.77	1	0.65	3	0.53
20	3	0.45	0	1.10	0	1.01	0	0.93	0	0.93
21	6	0.22	0	0.93	0	0.99	0	0.85	4	0.45
Median/ Mean	5	0.33± 0.18	0	0.90± 0.16*	0	0.91 ±0.13*	0	0.85± 0.16*	0	0.75 ±0.21*

RCC, Rutherford Clinical Classification. Least significant difference *t*-test, *$P<0.05$ (both compared with ABI/RCC before treatment). The median value is for RCC, and the mean value is for ABI, which were presented as mean ± standard deviation.