# A bare-metal stents treatment of arterial injuries at the joint levels

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Reports indicate that peripheral arterial injuries are especially challenging as they are associated with a high risk of limb loss. Rapid diagnosis and intervention is required to provide limb salvage and can be lifesaving. As endovascular techniques and tools continue to evolve, open repair has been not the only option in the management of traumatic vascular injuries. Similarly, minimally invasive percutaneous endovascular therapies offer an attractive treatment alternative. Limb salvage in acute traumatic vascular lesions may be improved because of the endovascular therapies to perform diagnostic evaluation and therapeutic intervention nearly simultaneously.

The covered stent is preferred to repair the injured lesions. However, as some crucial branch vessels generally stem near the joint levels, there is a high risk of coverage of branch vessels. The bare-metal stent may be a good alternative for endovascular repair with the advantage of preserving side branches, but little is known about efficacy and safety.[1] This study aimed to assess the feasibility and long-term outcomes of bare-metal stents implantation therapy in arterial injuries at the joint levels.

The study group performed a retrospective chart review on 16 patients presenting with peripheral arterial injuries at the joint levels between June 2005 and March 2014. The mean age was 49 years (range 34–71 years). There were thirteen car accidents, and three falls from height. Seven injuries were located at the knee joint, five at the elbow joint, two at the hip joint, and two at the shoulder joint. Pathology included complete transection ($n=2$), partial transection ($n=3$), pseudoaneurysm ($n=5$), arteriovenous fistula ($n=3$), and three intimal injury. All patients presented hemorrhagic shock. After arrival at our hospital, the mean blood pressure was 103/62 mmHg, and mean heart rate was $112 \pm 34$ beats/min.

To stanch bleeding and minimize the limb ischemia time, the researchers decided to perform urgent intravascular repair instead of surgical repair. Successful endovascular repair was defined as the restoration of blood flow confirmed by angiography at the end of procedure without contrast extravasation [Figure 1]. All patients received livelong antiplatelet therapy consisting of acetylsalicylic acid 100 mg daily after the operation. Planned post-operative evaluation included telephone contact, a physical examination, ultrasonography, and diagnostic angiography, at 1, 3, 6, and 12 months, and yearly after that—or whenever there was a symptom. Evaluation criteria were graft and branch vessels patency, limb loss, the presence or absence of other complications, and death. Diagnostic angiography was performed if symptomatic stent-graft stenosis or occlusion were suspected. The researchers recommended angiography at the last follow-up to obtain an objective assessment of stent patency.

All endovascular procedures were performed successfully without perioperative death and amputation. Twenty-one bare-metal stents were implanted. All stents were LifeStent (Bard Peripheral Vascular, Tempe, AZ, USA). The length of the stent ranged between 4 and 15 cm; the diameter of the stents was 6 mm. The mean duration of hospital stay was 18 days (range 8–46 days). During hospitalization, one patient was treated with intra-arterial thrombolysis due to stent thrombosis, and the patients had no problems during subsequent follow-up. None of the other operation related complications was found.

The average follow-up was $73 \pm 14$ months (range 60–106 months). Follow-up at 11 and 15 months showed two

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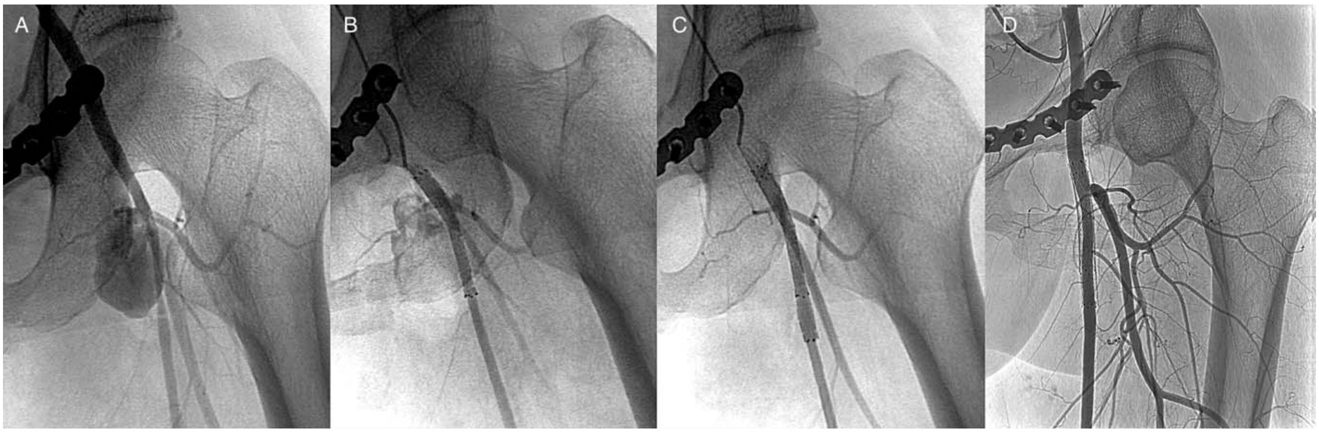


**Figure 1:** A 38-year-old woman was referred to our hospital due to pelvic fracture. Emergent selective angiography demonstrates the pseudoaneurysm of the femoral artery (A). A 6 mm × 40 mm bare-metal stent was implanted to stop bleeding while avoiding the coverage of the profound femoral artery. Subsequent angiography demonstrates less contrast extravasation (B). After the position of another 6 mm × 60 mm bare-metal stent, the contrast extravasation disappeared (C). The 96-month follow-up showed that the stent was embedded in the neointimal hyperplasia without fracture. Satisfactory blood flow was noted at the femoral artery (D).

patients presented with non-incapacitating claudication. Subsequent arteriography revealed significant (>50%) stent stenosis. The stenotic lesions were successfully treated with angioplasty and remained patent on monitoring. Fifty percent of patients had at least one arteriography at follow-up during the study period. The results revealed satisfactory blood flow at the stents and branch vessels and did not found stent migration, deformation, or fracture [Figure 1]. Overall, all 16 patients were alive, actively using their limbs without symptoms such as collateral vessel occlusion and stent fracture.

Acute traumatic arterial injuries to the peripheral arteries near the joint levels are uncommon but remains a challenging problem, and particularly there are main branch vessels. Therefore, the effect of the stent on the branch blood flow must be considered. The conventional techniques of endovascular treatment are coated stent deployment, which is believed helpful for maintaining blood flow. For injured arteries near the joint levels, the potential of a coated stent to cover the origin of the branch artery, leading to acute ischemia, remains.[1] In this study, the bare-metal stents, rather than coated stent-grafts, were implanted to avoid the coverage of branch vessels near the joints. The bare-metal stents have been proven as an effective approach for complex aneurysm and may effectively isolate the thoracic aortic aneurysm. A bare-metal stent may act as a passive barrier by reducing blood flow near the injury site.[2] The changed hemodynamic condition may also promote the activation and aggregation of platelets.[3] The results contained in this study further elaborate on the application of the bare-metal stent for repair peripheral vascular trauma.

According to the conventional concept, such repairment near joint levels remain infrequent primarily due to the potential risk of fracture. Although the stent may be prone to fracture because of mechanical forces by the motion of the joints, the endovascular repair seems to be a promising strategy to stop bleeding without any structural damage. It may be attributed to the improved radial strength and the ability to recover from being crushed.[4] The lower stress on the stent may be an essential protective factor for stent migration, deformation, or fracture. A study designed to identify the effect of biomechanical deformations on stents revealed that different bare-metal stents exhibit a variable ability to withstand chronic deformation *in vitro*.[5] The most likely explanation is the considerable differences in stent patterns because the stent pattern has a tremendous impact on the amount of localized strain experienced by a strut. Lifestent stent used in this study is more susceptible to axial stress, while repetitive bending does not lead to any fracture. As the wall of the injured arteries were in the normal range, a low axial compression is noted, which is the main reason for the favorable prognosis. Moreover, it has been proven that acceptable results can often be achieved after the treatment of relatively short segmental lesions. As the length of the injured lesion was limited, the implanted stent was shorter than 10 cm, which may be another protective factor.[4]

Previous studies have indicated a comparatively high rate of late clinical failure after stent implantation in the treatment of chronic limb ischemia because of thicker neointimal formation.[5] Unlike the chronically occluded artery, the thickness and the lumen of the artery wall are general within the physiological range. A low-stress effect of the implanted stent on the arterial wall was noted, which may not result in apparent neointimal hyperplasia. Rather than dilating the artery lumen, the stent was applied mainly to cover the injury site, which did not impose high stress on the artery wall. As stent forces alone are an essential risk for the vessel-wall response, low-strain is related to relatively low levels of hyperplastic or hypertrophic activity.[6] Therefore, intimal thickening did not obviously increase. Additionally, as the crucial mechanical-chemical signal transduction transmission remains,[7] the vascular endothelium might be directly stimulated by joint motion. Moreover, the special local hemodynamics near the joint may alter the blood-flow patterns and wall shear stress frequently, possibly leading to vascular adaptation and remodeling.[7]

This study has several limitations: because the study group focused on arterial trauma at the joint levels, the number of cases was limited and, therefore, subjected to reporting bias. Furthermore, data on follow-up time were inconsistent. Despite these limitations, the study demonstrates the advantage of bare-metal stents to preserve side branches, and the bare-metal stents implantation therapy in the treatment of arterial injuries at the joint levels is safety, feasibility, and efficacy.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s)/patient's guardians has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the article. The patients/patient's guardians understand that their names and initials will not be published and due efforts will be made to conceal the identity of the patient, although anonymity cannot be guaranteed.

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### Conflicts of interest

None.

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