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Septic non-unions of the leg treated by Papineau's technique in the orthopedic traumatology department of Owendo University Teaching Hospital: About three observations

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Abstract
Introduction: The management of septic non-union remains controversial. The Papineau technique is an alternative to achieve the objective of infection control and bone consolidation, in hospital structures where microsurgery is not available. The aim of this study was to describe the epidemiological aspects and evaluate the results obtained, in the department, after the use of this technique in three patients with septic leg non-union.
Observations: These were three patients, all male, whose average age was 39.3 years with a range of 28 to 49 years, who presented a septic pseudarthrosis of the leg with bone defects, following of a road traffic accident and who were treated and followed in the department between May 2019 and May 2022. The three patients were treated using the Papineau technique and their evolution was marked by total wound healing and consolidation bone after a minimum of three months.
Conclusion: septic non-union of the leg is the prerogative of young adult males, victims of road traffic accidents. The Papineau technique makes it possible to eradicate the infection and obtain bone consolidation. It has the advantage of being carried out with few resources and of being practiced in hospital structures with limited technical platforms.

Keywords: Septic pseudarthrosis, leg, Papineau technique, bone consolidation, CHUO

Introduction
Leg pseudarthrosis is the definitive absence of consolidation of a diaphyseal fracture of the two bones of the leg or the tibia, after an average period of six months classically leading to the creation of a new joint [1]. Pseudarthrosis of the tibia remains the most common of long bones due to the frequency of open fractures and its anatomical characteristics: no muscle mass or vascular replacement in the distal third of the leg [2]. Poor therapeutic indications and late management of open fractures are additional risk factors [3].
Septic Nonunion combines two major progressive complications: Nonunion and infection. It therefore poses two simultaneous problems: The first is the bone problem with both the reconstruction of the bone defect and its consolidation. The second is the infectious problem, it is a formidable complication which remains a major challenge for the orthopedic surgeon. Many techniques are used today to treat this condition, but none is unanimously accepted [4, 5].
In 1973, Papineau [6] introduced open bone grafting to treat these lesions. Its technique described by Roy-Camille R, *et al*. [7] takes place in three phases: first tissue and bone excision, then bone stability with unilateral external fixation and finally coverage of the wound by skin graft. The first phase consists of a wide excision of the infected soft tissues, with bacteriological samples, while respecting the posterior cortex which will be trephined using a 2.7 drill bit.
In the presence of a sequestrum, a sequestrectomy is carried out with excision, using a chisel, of the necrotic or sclerotic bone tissue until blood beads up on the cut edge. The drill holes resulting from the trepanation are curetted and the medullary canal repermeabilized.

From then on, osteosynthesis using an external fixator is performed followed by careful cleaning of the wound, first with Dakin, and then with physiological serum; the cavity is filled with tulle gras sausages. A pressure dressing is applied to open after 12 days. Papineau's second phase consists of performing an open autogenous bone graft using spongy bone samples from the iliac crest sutured tightly. At the graft recipient site, the tulle gras rolls are removed, then the walls are carefully cleaned with Dakin's solution and physiological serum, placing enough grafts so that they overflow the bone cavity. These grafts are covered with two sheets of tulle gras and an occlusive dressing to be opened on the 3rd post-operative day. As soon as the dressing is opened on the 3rd post-operative day, daily irrigation of the grafts begins by letting a liter of physiological serum flow drop by drop for two hours. Irrigation continues daily until all the grafts have been invaded and covered by fleshy buds. The third phase begins after noting the presence of a directed fleshy bud: this involves covering the wound with thin-skinned skin grafts.

In our country, studies concerning the use of the Papineau technique in the treatment of septic Nonunions of the leg have not yet been carried out. The aim of this work was to describe the epidemiological aspects and evaluate the results obtained after the use of this technique in the service. We report 3 cases of septic leg Nonunions treated in the department, using this technique, from May 2019 to May 2022.

Observations

Patient No. 1: This was a 49-year-old man, tradesman, right handed, with a surgical history of osteosynthesis of the right leg using a Hoffman 2 type external fixator in May 2019, indicated in front of a open right leg fracture classified Gustilo - Anderson type IIIa. The intervention would have taken place, at the Owendo University Hospital Center, at H8 of a road traffic accident which took place at the PK 12 market with a direct pedestrian-auto impact mechanism. After the operation, the evolution was marked by an infection of the surgical site. Follow-up was done externally, with regular dressings in the medical center close to the family home. After 9 months of dressings without healing, the evolution was unfavorable with fasciocutaneous necrosis and bone exposure, prompting a new consultation in the department. After clinical and paraclinical examinations, the diagnosis of hypertrophic septic pseudarthrosis was made. The treatment began with a drying period using acrylic cement beads loaded with gentamycin with a view to performing the Masquelet induced membrane technique [9]. Due to lack of financial resources due to the cost of very expensive bone cement, the Papineau indication was given, the intervention took place in three stages as described above. The evolution was satisfactory, the beginning of corticalization of the spongy graft was observed radiologically after 2 months, the wound completely healed after 3 months, the radiograph showed new bone formation, partial support was possible after 4 months and total support beyond 6 months. (Figure 1)

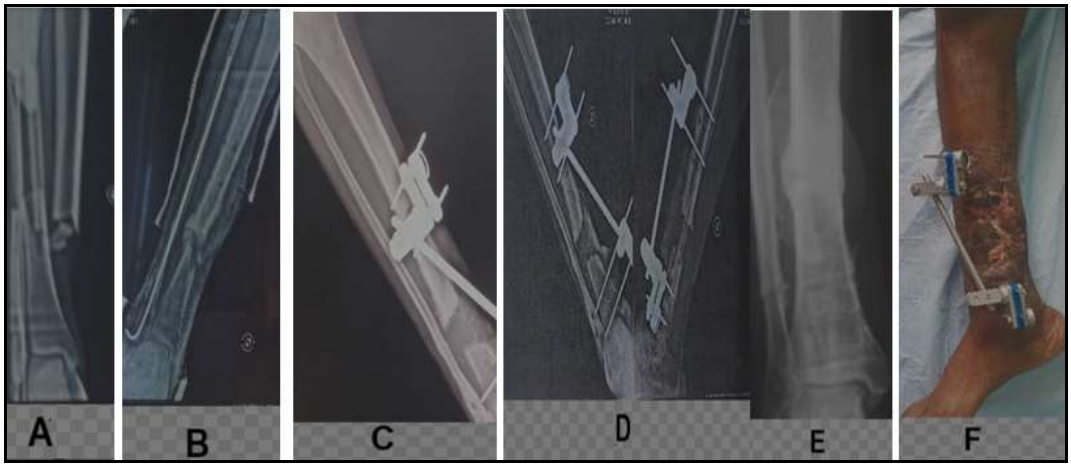

Fig 1: a 49-year-old man with septic pseudarthrosis of the right leg. A: initial x-ray of the tibia, frontal view. B: leg x-ray at the time of diagnosis of hypertrophic septic pseudarthrosis, frontal view. C: 1st stage of Papineau. D: 2nd stage of Papineau. E: bony consolidation of pseudarthrosis. F: Wound healing

Patient No. 2

It was a 41-year-old man, professional driver, right-handed, with a surgical history of osteosynthesis using an external fixator of the right tibia placed in May 2020, indicated for an open leg fracture. right classified Gustilo - Anderson type IIIa. In the history of the disease, the ACR would have taken place in the urban center of Ndjolé, in May 2020, by a self-obstructing high energy mechanism. Due to lack of technical facilities, he was transported to the regional hospital of Lambaréné where he benefited, at H36, from osteosynthesis using a Hoffman type external fixator reinforced by a cerclage at the fracture site. The postoperative course was marked by an infection of the surgical site with tissue necrosis. Faced with this situation, the patient underwent a new operation (extended necrosectomy with removal of the external fixator and immobilization with a fenestrated cruropedial cast to facilitate post-operative dressings. After leaving the hospital, the patient was lost to follow-up. 17 months later, he reappeared in our department where, after clinical and paraclinical examinations carried out, the diagnosis of septic pseudarthrosis of the right leg was made as well as the indication of the Papineau technique given the financial precariousness of the patient. The postoperative evolution was satisfactory, the wound completely healed after 3 months, the beginning of corticalization of the spongy graft was observed radiologically after 3 months and the images also showed new bone formation; partial support was possible after 4 months and full support beyond 6 months (Figure 2)

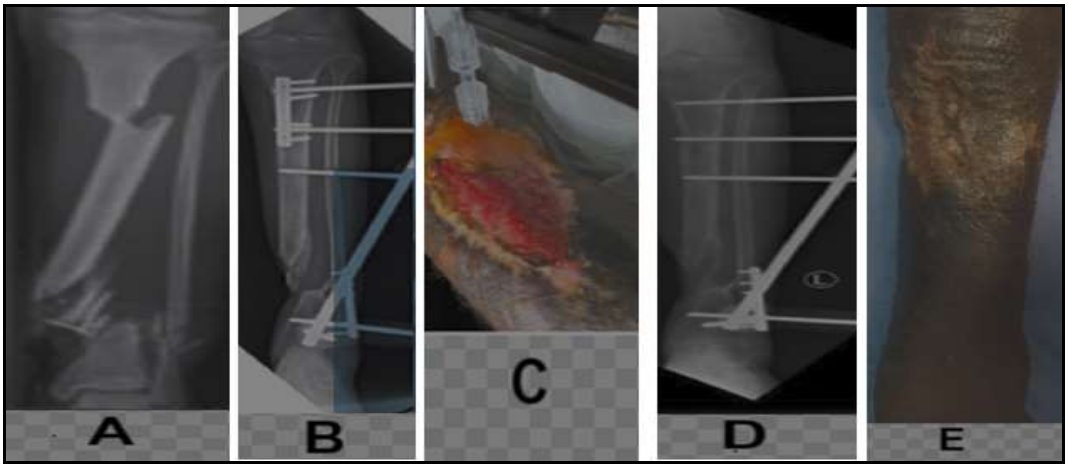

Fig 2: a 41-year-old man with septic pseudarthrosis of the right leg. A: initial x-ray of the tibia, frontal view. B: leg x-ray at the time of diagnosis of septic pseudarthrosis, frontal view. C: fleshy bud stage after a long period of irrigation. D: bone consolidation. F: Healing of the wound.

Patient No. 3: Mr. B.M.B. aged 28, tree feller, with a surgical history of osteosynthesis of the left tibia using an external fixator of the orthofix type installed in June 2022, indicated for an open fracture of the left leg classified as Gustilo-Anderson type II. In the history of the disease, the patient was the victim of a logging accident in a Cocobeach forest, the mechanism was a direct impact of a tree trunk on the leg. Initial treatment would have taken place at the Kango dispensary at H6 of the incident with decontamination of the wound, a sterile dressing and the installation of a makeshift splint. Then the patient would have been transferred to HIAOBO, in a non-medical vehicle. On his arrival, he would have benefited from a second decontamination and the placement of an orthofix type external fixator. After leaving the hospital, the patient continued his oral treatment of antibiotics and anticoagulants as well as regular dressings, externally. Faced with the absence of progression of the wound despite the dressings, the person concerned consulted our department again 8 months later where, after clinical and paraclinical examinations, the diagnosis of septic pseudarthrosis was made as well as the indication of Papineau's technique given his financial precariousness. After the operation, the progress was satisfactory, the wound had completely healed after 3 months, within the same time frame, we observed the beginning of corticalization of the spongy graft; the images also showed new bone formation; partial support was possible after 4 months and total support beyond 6 months. (Figure 3).

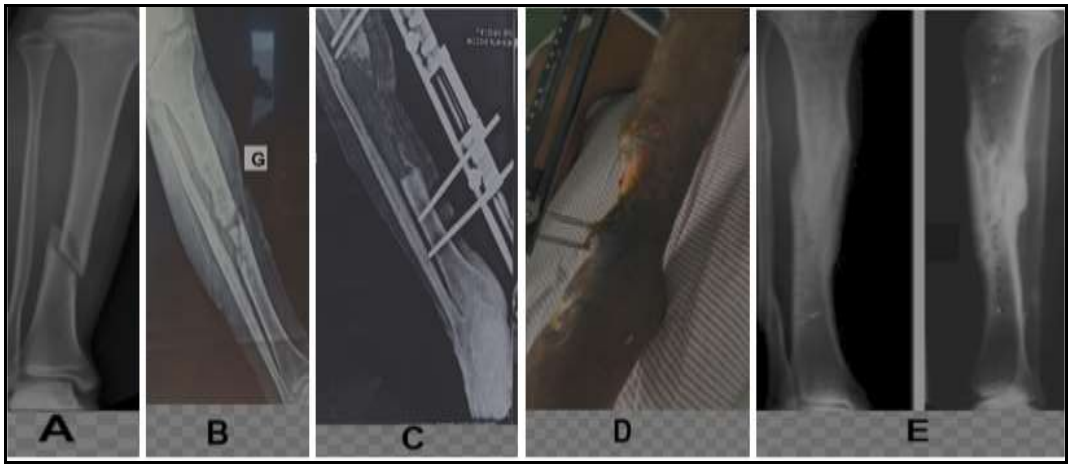

Fig 3: a 28-year-old man with septic pseudarthrosis of the left leg. A: initial radiograph of the left tibia, frontal view. B: left leg radiograph at the time of diagnosis of septic pseudarthrosis, frontal view. C: 1st stage of Papineau. D: 2nd stage of Papineau. E: bone consolidation.

Discussion

Our study confirms that septic non-union of the leg is the prerogative of young adult males and that RCAs are the major contributors to this pathology. This result is comparable to that of BOUZIDI *et al*. [10] who found, in their series, a mean age of 36 years with extremes ranging from 20 to 64 years for post-traumatic non-unions of the leg; this could be explained by the frequency of leg fractures in this group of patients. The male predominance could be explained by the greater mobility and riskier behavior of men behind the wheel.

Several techniques have been described to reduce large soft tissue and bone defects, including open or closed bone grafting [11], local or free muscle flap [12], and open or closed wound irrigation with suction [13]. The Papineau technique was developed to facilitate the management of difficult bone defects of septic Nonunion or post-traumatic osteomyelitis. This technique involves extensive curettage, removal of necrotic bone or unhealthy granulation in cases of infected Nonunion of the long bones [9].

In this series, we found that all patients achieved union at an average rate of 4 months without any complications. Bao *et al*. [14] treated 19 patients with open tibial fractures with soft tissue and segmental bone defects using the Papineau technique associated with negative pressure-assisted closure (Vac Thérapie). Bone union was achieved in all patients with a mean of 33.88±8.37 weeks (range: 25-33). Kérargyris *et al*. [15] treated

seven patients (mean age 32 years) with septic Nonunions of the tibia with the Papineau technique combined with vac therapy. All patients were healed at an average of 29 days. None experienced a recurrence of the infection. Other studies have reported high success rates for the treatment of chronic bone infections [16, 17]. The three difficult issues related to severe open tibial fractures are infection prevention, bony union, and soft tissue coverage. Cover bone graft for repair of an infected bone defect can be divided into three stages: (1) complete debridement of all necrotic and infected bones; (2) the bone graft is spongy and covered by the hematoma; (3) local wound care until coverage with granulation tissue followed by epithelialization and skin grafting. Compared to other methods of repairing bone defects, the Papineau technique simplifies the repair by avoiding covering the wound with flaps.

It allows adequate debridement and decortication to remove sequestering and fibrous tissue. Thus, this creates an environment conducive to promoting bone union. Such a technique also allows drainage by wound closure which is not closely approximated, this promotes the formation of epithelialization of healthy granulation tissues, essential for bone consolidation [18]. Some surgeons have confirmed that the one-stage procedure can achieve satisfactory results [19, 20] provided that a large and careful debridement is performed because inadequate debridement increases the risk of recurrence of the infection and therefore graft failure. All patients achieved a normal full weight-bearing range and the leg returned to more or less normal function. Our study has limitations due to the small number of subjects, further studies are needed to investigate the safety and effectiveness of the Papineau technique to treat tibial bone defects. In addition, this technique is limited by delayed healing of the wound, requiring the use of an external fixator.

Conclusion

With one case per year of septic pseudarthrosis of the tibia, we can affirm that it is a rare condition in the service. Young male adults are most exposed to this pathology. The Papineau technique alone can achieve successful eradication of infection, reconstruction of bone defects, and closure of soft tissues. Furthermore, such a technique can be carried out with little means, and it could be practiced in small health centers with limited facilities. However, this technique has limitations linked to the delay in wound healing and the need to use external fixators to stabilize the leg segment.

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Conflict of interest

The authors declare that they have not known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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