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Review Article

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Computer Navigation-Assisted Resection of Heterotopic Ossification around the Hip: A Technical Note

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Abstract

Heterotopic ossification is a rare but a debilitating situation. It occurs in patients who have undergone paralysis and/or immobilization. Hip osteoma is one of the most frequent locations and associated to a significant functional handicap. Its treatment is based on surgical resection which is a risky surgery and not deprived of complications such as infections, hematoma and recurrence. We describe in this paper a new surgical technique which adds to the classic hip osteoma resection a guidance with a navigation system coupled to a 3D imaging tool. We performed this technique in 2 patients (3 hips, 1 bilateral case). We think that this technique makes the surgery safer and lower the complication.

Keywords

Heterotopic ossification, Surgical navigation systems, CT-guided surgery, Hip

Introduction

Heterotopic ossification (HO) is an ectopic ossification in soft tissues around a joint. This bone development occurs in patients who sustained a trauma or a major neurologic injury. The hip is one of the most affected joints. It can cause significant pain and reduced range of motion which leads to marked impairment in quality of life.

Therefore, surgical resection of HO is necessary and sometimes urgent. This type of surgery is not without risks and should be planned and performed appropriately.

We present a new surgical technique for hip osteoma resection using the CT-guided navigation system which can make surgery simpler and more prudent.

Surgical Technique

Installation

The patient can be installed prone, supine or lateral. This will depend on the location of the osteoma and the approach. An orthopedic table or a radiolucent (carbon fiber) plateau can be used. This makes it easier to set up the imaging apparatus.

The intraoperative guidance is performed using a navigation system coupled with a 3D imaging (here, O-ARM imaging device Medtronic and Stealth station 7, Medtronic).

The imaging apparatus in positioned according to anteroposterior and lateral centering, then 'parked' at the patients' feet. The navigation screen is installed near the patient's head (Figure 1). Sterile draping includes the area where the surgical approach was decided (anterior, lateral, postero-lateral, Kocher-Langenbeck, Stoppa approach…).

Procedure

Surgery begins with a 3D image acquisition after positioning the reference frame with passive localizers fixed with 2 K-wires, either on the anterosuperior iliac spine (when the patient is in supine or lateral position) or on the posterosuperior iliac spine (when the patient is in prone position).

After the surgical approach, a navigation pointer shows the resection boundaries which are the iliac and the femoral implantations of the HO. The HO is exposed progressively by releasing the covering muscles with an electric cautery

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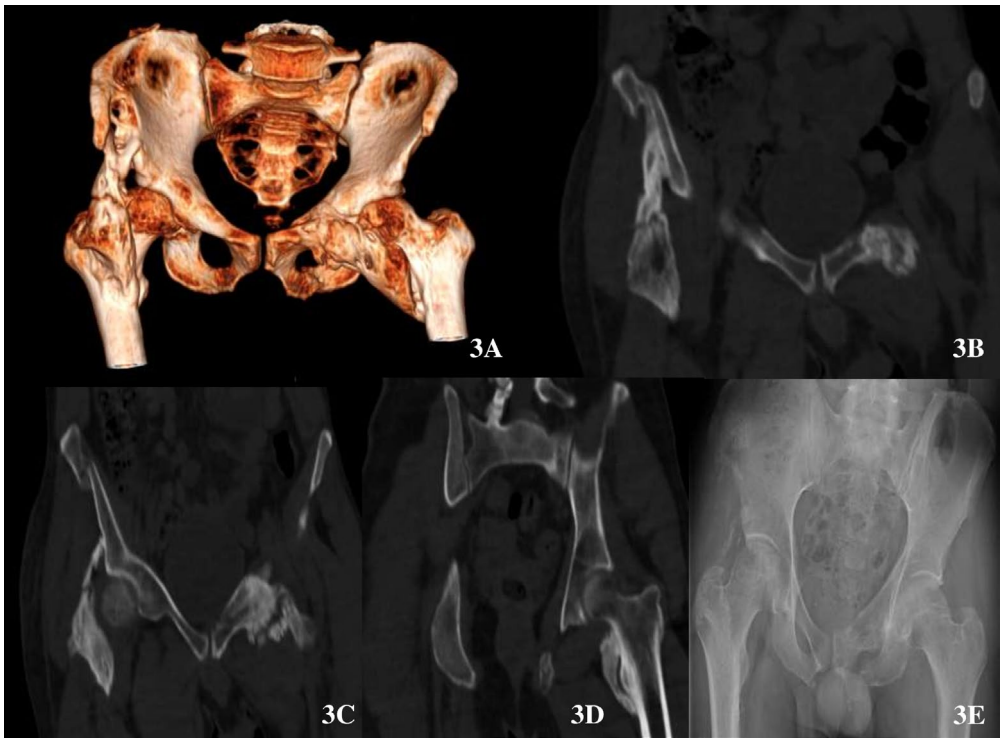

Figure 1: Example of a supine position installation on an orthopedic table. The O-arm is placed in the parking position on the side of the patient's feet. The navigation screen is placed at the patient's head.

to reduce bleeding. We perform a bone chisel cut on the HO implantation bases and we continue the exposure of the osteoma in order to excise it *en bloc* in the supra capsular cleavage plane. This resection is carried out with a meticulous control of nervous and vascular structures. Careful haemostasis is performed and 2 Redon drains are put in the dead zones of resection.

A two dimensional or three dimensional acquisition is performed at the end of the procedure in order to ensure the absence of residual osteoma that should be removed.

Patients

We performed this technique in 2 patients (3 hips). The first case is a 24-year-old man who was victim of a polytrauma following a motor vehicle accident. He had a right acetabulum and a femoral head fractures. An open reduction and internal fixation of these fractures by screws was performed. He developed a posterior osteoma of this hip a year later. He was operated on via the postero-lateral hip approach (Figure 2). The second case is a 40-year-old man who was a polytraumatized patient following a defenestration. He had a pelvis, sternum, scapula, right humerus and elbow, and left calcaneus fractures. He had a hepatic artery embolization and was operated on for an ischemic cholecystitis. For all that, he was bedridden for more than 2 months and developed a bilateral hip HO. This patient was operated on on both hips at the same time. We performed a Smith-Peterson approach on the right side and a Hueter approach to excise the femoral implantation combined with a modified Stoppa approach for the iliopubic branch implantation on the left side (Figure 3).

We didn't note any perioperative incidents. The 2 patients didn't receive a red cell blood transfusion during the immediate postoperative stay. They did not present infectious complications of the surgical site. We did not identify a recurrence of osteoma at a mean follow-up of 20 months.

Discussion

HO is an ectopic ossification in soft tissues around joints [1]. There are two forms of HO: A genetic and an acquired form [1,2]. It mainly affects the periarticular tissues of the hip [2-5]. The acquired forms of osteoma concern polytraumatized patients, who usually require a period of critical care for a trauma or a major neurologic injury such as traumatic brain injury, spinal cord injury, stroke and cerebral anoxia [3,4,6]. When it comes to the hip, HO also follows acetabular fractures or hip surgery (total hip arthroplasty) [7,8].

When HO become symptomatic, it associates pain, limited range of motion, a limitation of activities of daily living, especially in paraplegic patients the inability to sit in a wheelchair, limited personal hygiene with a high risk factor for the appearance of bedsores [1,5].

The management of hip HO consists of surgical resection which is a risky surgery with a high rate of complications especially infections, hematoma and recurrence [2,9].

All these arguments push us to better plan this surgery in order to achieve an appropriate execution. Thereby, we present our new technique that, we think, makes this type of surgical management safer intra- and postoperatively.

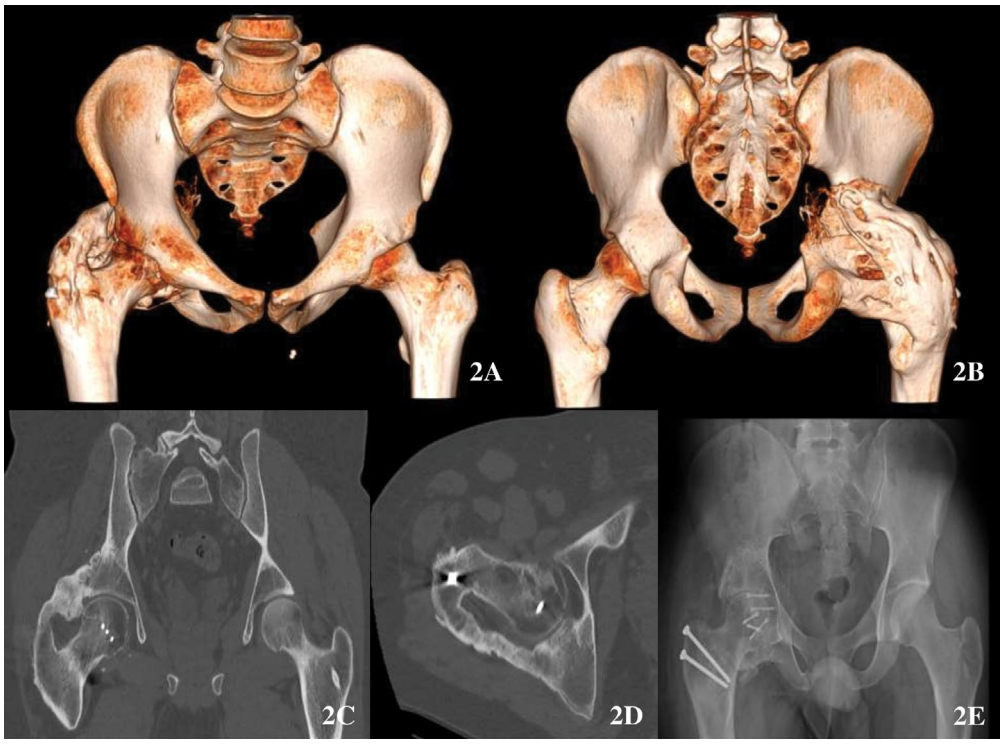

Figure 2: 1st patient: A,B) Preoperative pelvis 3D-scan image. C) Coronal view of the preoperative pelvis multiplanar reconstruction (MPR). D) Axial view of the preoperative pelvis MPR. E) Postoperative pelvis X-ray.

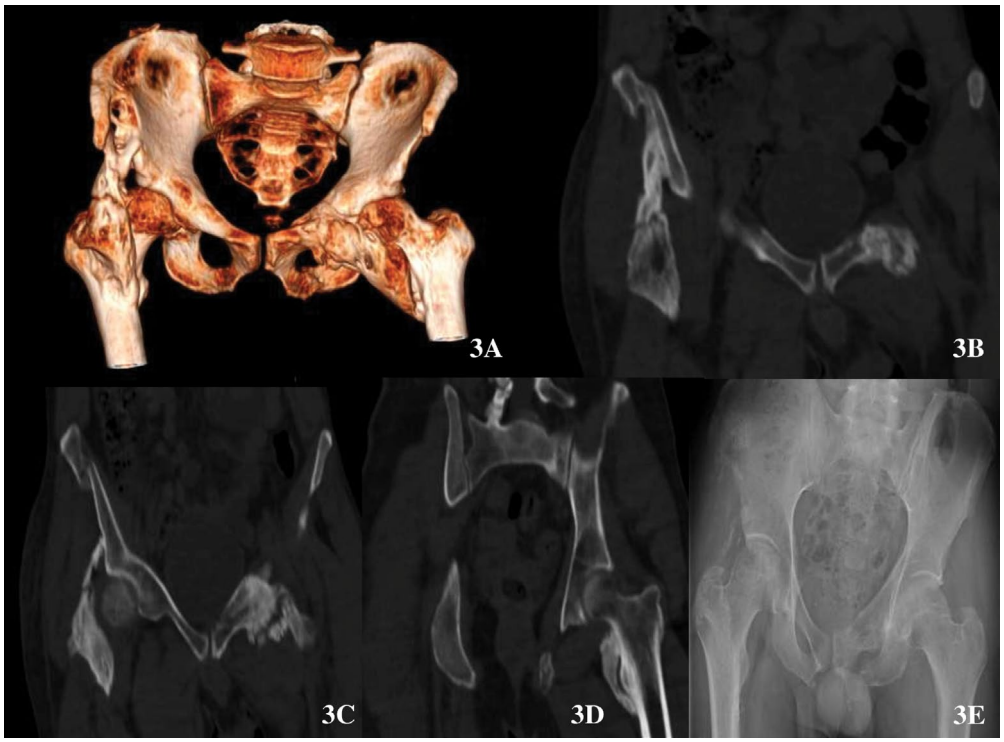

Figure 3: 2nd patient: A) Preoperative pelvis 3D-scan image. B) Right hip osteoma: Proximal iliac implantation. C) Right hip osteoma: Distal iliac implantation and left hip osteoma: Proximal implantation on the ilio-pubic branch. D) Left hip osteoma: Femoral implantation. E) Postoperative pelvis X-ray.

To our knowledge, this is the first publication concerning the HO resection using a CT-guided navigation system.

It is a technique that facilitates the intraoperative management. It was reported in the literature that preoperative 3D-CT imaging, complemented in some cases by angiography, allows the surgeon to define the 3D

anatomy of the HO accurately, their possible contact with the vasculo-nervous elements and plan the surgical excision with precision [10,11]. Therefore, we believe this technique with its intraoperative 3D image acquisition allows a precise and rapid surgery.

Concerning the surgical technique, Denormandie, et al. reported that the iliac and femoral implantation bases have to be determined as the first step of the surgery [3]. They added that, for fear of increased morbidity, resection shouldn't be exhaustive unlike in oncologic surgery. Only the part of the heterotopic ossification that is causing problems should be removed. For example, during excision, the normal bony contour guides the resection and should be well exposed especially in the femoral implantation in order to avoid iatrogenic fractures [3,12]. In our technique, the navigation pointer makes easier to go directly to the target which is the implantation bases of the HO. This allows making a quick and efficient bone chisel cut where it should be. It allows also an *en bloc* resection of the osteoma. On another side, heterotopic ossifications are always extra-articular and develop around joints. The capsule is always conserved and constitutes a cleavage plane [3,4]. This cleavage plane whereby resection must be controlled can be guided by navigation in our technique.

Navigation use for this type of surgery allows us to perform exactly what was planned thus shortening operating time. Consequently, this can decrease the rate of infections and intraoperative bleeding. Postoperative care will be more comfortable for patients and start rehabilitation as soon as possible. Moreover, it allows us to operate on both hips at the same time, just like we did with our second patient, considering that bilateral hip HO are frequent [5].

However, like any surgical technique, it has limitations. This technique requires a specific technical platform. Surgeons must have a navigation system available in the operating room coupled with a 3D imaging tool and have a good command of it.

Finally, Stoira, et al. recently published a paper stating a high prevalence of heterotopic ossification in critically ill patients with severe COVID-19 [13]. They reported that prolonged immobilization as a result of longer sedation and neuromuscular blockade for severe acute respiratory distress syndrome has played a decisive role for HO in their patients. However, it is plausible that other factors, such as systemic inflammatory condition and local myositis, possibly due to the SARS-CoV-2 virus, might have contributed to the higher prevalence of HO [2,13]. This technique may prove to be more necessary nowadays, apart from its other indications, because of the Covid-19 pandemic.

Conclusion

The CT-guided navigation when available and well commanded may be of great help in the case of HO resection. This concerns the intraoperative management and postoperative care. It's a judicious technique whose results should be studied over larger series. This takes part of our goals in the future.

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