CASE REPORT

Resection of a physeal bar under computer-assisted guidance

Excision of a physeal bar and filling the space with interposition material may allow resumption of normal growth. Both the extent and the location of the bar and the amount of growth remaining from physis must be determined. Computer-assisted surgery is being used increasingly in various fields of orthopaedics. We describe the management of a patient with premature physeal arrest of the right distal tibia in which resection of a physeal bar was achieved under real-time three-dimensional intra-operative monitoring by computer-assisted navigation.

The advantage of this method over other means of imaging is that intra-operative identification can increase the accuracy of resection of the bar.

Disturbances of growth may be caused by the development of a physeal bar across the physeal cartilage. The management of physeal bars is considerably easier when they are identified early, because treatment can be directed solely toward resolving the arrest, rather than addressing both the arrest and an acquired deformity of growth. Excision of a physeal bar and filling the space with interposition material may allow the resumption of normal growth. The extent and location of the bar must be determined and the remaining physis must remain undamaged.

The anatomy of a physeal bar may be delineated using plain radiography, tomography, CT or MRI. Carlson and Wenger have described a method of producing a schematic cross-sectional map on graph paper using data obtained from biplanar polytomography. They found that this helped identify lesions that could be treated surgically and aided the planning of the operation. However, the map has some limitations, as the precise extent of the lesion is difficult to identify under intra-operative fluoroscopic guidance, even though the precise location and size of the bar has been determined. Computer-assisted surgery has increasingly been used in various fields of orthopaedic surgery. Navigation systems have been introduced for intra-operative guidance as an alternative to fluoroscopy, and can use information from CT images to improve operative visualisation. Their use enables intra-operative identification of the extent of a physeal bar and allows more accurate surgery.

We describe an illustrative case of premature physeal arrest treated with computer-assisted resection of the physeal bar.

Case report

An eight-year-old girl sustained an injury to the physis of the right distal tibia in a motor vehicle accident (Fig. 1a). The fracture was treated by closed reduction and a cast. After five months the radiographs and a three-dimensional (3D) CT scan demonstrated partial physeal arrest involving a Kump's bump with no deformity and without noticeable shortening (Figs 1b to 1d).

We undertook minimally invasive surgery using a CT-based navigation system (In2vision, Cybermed, Seoul, Korea). We attached adhesive fiducial markers (Multi-Modality Markers, IZI Medical Products, Baltimore, Maryland) to the leg and acquired CT images (LightSpeed Pro 16; GE Medical Systems, Waukesha, Wisconsin) with unenhanced 0.6 mm thin slices. The scan data were transferred to a computer workstation and reformatted into coronal, sagittal, axial and 3D views. The patient was moved to an operating theatre, where a tourniquet was applied under general anaesthesia. After two threaded pins had been inserted into the tibial cortex, a fixed-base tracker was mounted using a universal connector. We performed paired-point registration between the navigational images and the markers. The registration error, automatically calculated by the navigation system, was 0.7 mm and the accuracy of the images was verified...
using a navigated pointer. Using this system, the location of the physeal bar was confirmed, and the entry point and trajectory of a drill hole directed toward the physeal bar were mapped. A navigated, high speed 2 mm burr was attached to the universal tracker. Next, we made a 5 mm incision and created a bony hole using a burr (Fig. 2a) under real-time 3D monitoring (Fig. 2b). When its tip reached the bar, further burring was double-checked using fluoroscopy. We confirmed that a void had been created by injecting contrast dye (Ultravist, Bayer Schering Pharma, Seoul, Korea) and fluoroscopic imaging. A 10-gauge biopsy needle was placed in the resected area of the physeal bar and localised fluoroscopically. The void was then filled with 1.2 ml of methylmethacrylate (Cranioplastic, Codman & Shurtleff, Inc., Randolph, Massachusetts). An allograft of cancellous bone chips (Community Tissue Services, Dayton, Ohio) was grafted into the hole in the metaphyseal cortex created by the burr. A metallic marker for further growth was placed in the diaphysis using one 2.7 mm cortical screw. We confirmed successful resection of the physeal bar and the placement of a well-seated cement mantle on post-operative reconstructive coronal and sagittal CT images (Fig. 3). The total surgical time was 70 minutes, with 30 minutes for the pre-operative preparation, including patient positioning, draping and the set-up of the navigation, and 40 minutes for the main operation of resection of the physeal bar, filling with methylmethacrylate cement and fixation of the metallic marker. The estimated radiation dose was a dose-length product of 39 mGy cm.

After operation a short leg splint was applied for two weeks and partial weight-bearing was maintained for four further weeks. Plain radiographs obtained after one year showed that the physeal bar had not recurred (Fig. 4).

**Discussion**

Resection of a physeal bar is indicated when less than 50% of the physis is damaged and more than two years of growth remain in the affected growth plate.9,10 Peripheral physeal bars are typically approached directly, with excision of the overlying periosteum and removal of abnormal bone until the normal physeal cartilage is uncovered. This procedure may eliminate the need for osteotomy if the angular deformity is < 20°. Central bars are approached through a metaphyseal window or through an osteotomy.
registration requires the complex exposure of the cortical bony surface around lesions. The two methods may be used together when resecting malignant bone tumours, a procedure that usually requires extensive bony exposure.4-6 We prefer paired-point registration using skin-adhesive fiducial markers rather than surface registration, because it does not require exposure of the bony surface. Although Kirschner wires, which are temporarily implanted into bone preoperatively under local anaesthesia, may be considered as fiducial markers,3 the procedure can be invasive in young patients. Computer navigation-guided surgery with skin registration using adhesive fiducial markers may be used in neurosurgery,15 but not in operations on the extremities because of the changes in the relationship between skin and bone when moving position. However, the anteromedial subcutaneous border of the tibia is very similar to the scalp, in that the skin is closely adherent to bone. Our error for registration was < 1 mm using an adhesive fiducial marker. Nagashima et al16 found that it was necessary to monitor the accuracy of lesion-targeted bony holes when using navigated pointer probes with frequent pauses during the introduction of burrs in navigated surgery for osteoid osteoma at C2. We directed the trajectory of the high-speed burr by attaching a universal tracker to a burr handle. This enabled real-time 3D monitoring of the bony route without interrupting surgery. The construction of a virtual trajectory between the tip of the burr and a bony target prevents drilling errors during surgery. We were able to successfully complete resection of the physeal bar in our patient through a skin incision that was < 1 cm long.

We have shown that the techniques of computer-assisted navigation can be applied to resection of a physeal bar. The accuracy of intra-operative identification using such navigation systems facilitates precise resection of the bar and helps preserve the normal physis through the use of a minimal incision.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


