

## **SUPPLEMENTARY RESULTS**

### **Survivors case reports: surgical occipito-cervical stabilization**

Patient #2: in the operating room, attempts to manually reduce the separation by the way of head positioning were only partially successful. A posterior midline approach was used to expose from the occiput to C3. Due to left VA anatomy, no screw was placed at C2 left side. Thus, a screw was placed into the C1 left lateral mass. Next, a right C1-C2 transarticular screw was placed. Additional lateral mass instrumentation at C3 was performed. An occipital plate of the appropriate size was secured to the occipital bone. Titanium rods were shaped, so as to reduce the deformity and to reapproximate the bony surfaces placed and secured to the screws and plate. Additional decompression via laminectomy was performed. The exposed bone was decorticated carefully, and an arthrodesis was accomplished with autograft and hydroxyapatite. Routine wound closure was performed. Halo immobilization was not used, whereas only a rigid cervical collar was applied after surgery.

Patient #5: The same technique of direct internal occipito-atlanto-axial fixation was performed, with placement of occipital and C1-C2 transarticular screws as described in the previous case. A rigid cervical orthosis was applied after surgery for 6 weeks. He continued recovery on a rehabilitation facility.

## SUPPLEMENTARY FIGURE LEGENDS

**Supplementary Figure 1. Patient #3. A-D:** subarachnoid haemorrhage (SAH) and intraventricular haemorrhage (IVH). Arrows depict perimedullary SAH. **E-F:** left vertebral artery dissection (white arrows). **G:** bilateral widened CCI, but the left OC1 joint has very little contact surface (arrows) because the left condyle has swung forward from the C1 facet. **H:** Powers' ratio, Wholey's BDI, and Harris' BAI criteria were positive. In contrast, X-line criterion was normal. **I-J:** Left (I) and right (J) sagittal images showing the considerable distraction and anterior displacement, leaving hardly any overlapping surfaces available for CCI measurements. **K-L:** Jefferson fracture involving the anterior and posterior arches of C1 without displacement of the fracture fragments.