Keyhole clipping surgery
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Introduction: Safe and less invasive aneurysmal clipping surgery are needed in the modern neurosurgical era. Clipping via keyhole surgery is one potion for treating cerebral aneurysm. We developed a tailor-made method based on surgical simulation using three-dimensional (3D) imaging of individual patients to allow safe performance of keyhole clipping surgery for unruptured aneurysms.

Objectives: A total of 200 tailor-made keyhole clipping surgeries have been performed in 190 patients between July 2005 to March 2011. 115 middle cerebral artery (MCA) aneurysms were treated via pterional keyhole approach (Mori K, et al, Minim Invas Neurosurg 2007), 49 anterior communicating artery (ACom) aneurysms were treated via lateral supraorbital keyhole (Mori K, et al, Minim Invas Neurosurg 2008), and 36 internal carotid artery (ICA) aneurysms were treated via supraorbital keyhole (Perneckzky method). Because of limited working angle, the indication for keyhole clipping surgery is basically limited with diameter of less than 10 mm.

Methods: 3D images were reconstructed of the skin, skull, cerebral arteries and veins, and aneurysm. The size, shape, and location of the scheduled keyhole and the patient’s head position were individually optimized using this preoperative computer simulation system. The site of opening of the sylvian fissure was also preoperatively determined according to the spatial relationships between the aneurysm and sylvian veins in the cases of MCA aneurysm. Monitoring of muscle motor-evoked potentials (MEPs) during surgery was performed by transcranial electrodes. Without scalp hair shaving, the eyebrow or periorbital skin incision of about 4 cm was made. The antero-superior part of the temporal muscle was subperiosteally dissected. The keyhole mini-craniotomy was reproduced exactly as indicated by the simulation. Clippings were performed with or without endoscopic observation. The MEPs were carefully examined and checked for changes after the clipping procedure. ICG video-angiography confirmed complete clipping. No drain tube was placed.

Results: Neck clipping was successfully performed in 206 aneurysms and wrapping for 1 blister-like aneurysm. Clipping of 4 aneurysms resulted in neck remnant and 1 was later clipped via conventional craniotomy. The mean maximum diameter was 25 ± 2 mm in the pterional keyholes, 27 ± 3 mm in the lateral supraorbital keyholes, and 29 ± 2 mm in the supraorbital keyhole. Magnetic resonance imaging detected lacunar infarction in 6 cases (3%, two: symptomatic, 4: non symptomatic) but no other abnormalities. The modified Rankin Scale at 3 months after the operation was Grade 0 in 198 cases (99%) except two patients with mild dementia (Grade 1) and hemiparesis (Grade 3). Mini-mental state examination and Hamilton rating scale for depression test were significantly improved after the
operations. 45 patients (23%) discharged next day and 95% of the patients discharged within 3 days after the operation.

**Conclusions:** Keyhole clipping surgery based on careful surgical simulation with 3D images is safe and less invasive to treat relatively small unruptured cerebral aneurysms.