From frame to frameless—framing the evolution of neurosurgical head holders

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Abstract Number: 37351
Disclosures

No relevant disclosures.
Introduction

- Over the past century, many neurosurgeon-inventors pioneered innovations in head fixation that have improved the safety, comfort, and efficiency of cranial procedures (Fig. 1).

- We detail the evolution of head fixation from early developments to modern iterations of the head holder.

Figure 1. Overview of the history of neurosurgical innovations of the past century
Methods

- We conducted a comprehensive literature review on the evolution of neurosurgical head holders over the past century.
Results

- At the start of the twentieth century, Thierry De Martel (1875-1940) engineered a neurosurgical chair that kept patients seated upright and utilized a patient’s arms to position their head (Fig. 2).
- Head holders subsequently evolved to address diverse procedural needs.
- Innovators such as Harvey Cushing (1869-1939) and Alfred Adson (1887-1951) developed headrests for procedures in the prone position to accommodate administration of anesthesia to a patient’s airway.

Figure 2. A-E) Images from De Martel’s surgical manual *Blessures du crane et du cerveau* (1917)
Results

- To address complex procedures requiring particular positioning and surgical access, W. James Gardner (1898-1987) developed a versatile mechanical chair that was adjustable and could accommodate cranial and spinal surgeries (Fig. 3A).
- In times of war during the 1940s, detachable and portable head holders were developed to accommodate mass casualties (Fig. 3B).

Figure 3. A) Gardner’s versatile chair (JNS, 1917) B) US Navy Captain W. M. Craig’s portable head and shoulder operating table supports (JNS, 1944)
Results

- In the 1970s, Frank H. Mayfield (1908-1991) introduced the elegant three-pin skull clamp to immobilize the head during surgical procedures (Fig. 4A-B).
- In the 1980s, Kenichiro Sugita (1932-1994) and Koichi Matsuo introduced a four-pin head fixation system based on the “isocenter concept” to securely position and target lesions.
- These innovations in stereotactic head frames were integral to the microscopic procedures.

Figure 4. A) Mayfield 3-pin skull clamp (Integra, Plainsboro, NJ) B) Frank H. Mayfield and George Kees (Mayfield Clinic)
Results

- Starting with the COMPASS neuronavigation system of Patrick Kelly and Stephan Goerss in the 1980s, MR-compatible radiolucent head fixation gained widespread use (Fig. 5A-B).
- Gel pads and cushions composed of synthetic materials have made head stabilization less invasive and uncomfortable.
- Neurosurgeons now utilize electromagnetic fields to track surgical instrumentation during procedures, without necessitating rigid fixation.

Figure 5. A) Kelly’s stereotactic lesion resection system (JNS, 1988) B) Radiolucent skull clamp and pins (Pro Med Instruments)
Discussion

- The neurosurgical head holder has undergone incredible evolution in form and function since the early twentieth century.

- For modern neurosurgeons, state-of-the-art technologies have replaced the manual work required throughout the rich history of neurosurgery.

- Many modern head holder designs revert back to their historical form with minimal restrictions.

- Future head holders may incorporate real-time imaging for optimal patient positioning and even facilitate remote human operation.
Summary

- The head holder has undergone great evolution in form and function over the past century.

- Neurosurgical innovators, such as De Martel, Adson, Gardner and Sugita, have pioneered dynamic transformations, including chairs, operating tables, head clamps, and stereotactic frames.

- In the future, head holders will continue to advance for purposes far greater than supporting the head.