Neurosurgical cranial fixation device

- A novel minimally invasive neurosurgical cranial fixation device for improved accuracy of intraventricular catheter placement: an experimental animal study
- Multicenter Randomized Controlled Clinical Trial to Compare the Safety and Performance of Two Bone Flap Fixation Systems
- 3D printed headholder for use in neurosurgical cadaver training: Technical note
- Comparison of polymethyl methacrylate skull implant fixation by three types of titanium fasteners
- Pin penetration depths in the neurocranium using a three-pin head fixation device
- Use of Clamp-Like Devices to Fix Bifrontal Basal Craniotomies: Three Case Reports
- High-Accuracy Neuro-Navigation with Computer Vision for Frameless Registration and Real-Time Tracking
- Domestic software, medical devices and materials in surgery for hyperostotic craniofacial meningiomas

Cranial fixation devices are critical tools used in neurosurgery to secure bone flaps following craniotomies. These devices ensure the stability of the bone flap, promote proper healing, and protect the brain by maintaining the structural integrity of the skull. They vary in material, design, and application depending on the surgical requirements.

Types of Cranial Fixation Devices

Plates and Screws (P&S)

- **Material**: Commonly made of titanium, known for its biocompatibility and strength.
- **Design**: Plates are contoured to the skull, and screws are used to anchor the bone flap.
- **Advantages**:
  1. High stability and durability.
  2. Established use in a wide range of craniotomies.
- **Disadvantages**:
  1. Requires drilling into the bone.
  2. May cause patient discomfort due to hardware protrusion.

Clamp-Like Devices

- **Example**: Cranial LOOP.
- **Material**: High-strength biocompatible polymers.
- **Design**: Clamps grip the bone edges without the need for screws or drilling.
- **Advantages**:
  1. Less invasive, reducing trauma to the bone.
  2. Faster and easier installation.
  3. Improved patient comfort with minimal hardware protrusion.
- **Disadvantages**:
  1. Limited long-term data on performance.
  2. May not yet be validated for all surgical scenarios.

Resorbable Fixation Systems

- **Material**: Polymers that degrade over time (e.g., polylactic acid).
- **Advantages**:
  1. Avoids long-term implantation of foreign materials.
  2. Suitable for pediatric patients or temporary repairs.
- **Disadvantages**:
  1. Lower mechanical strength compared to permanent systems.
  2. Variable resorption rates depending on patient biology.

Custom 3D-Printed Fixation Devices

- **Material**: Titanium, polymers, or composite materials.
- **Design**: Tailored to the patient’s anatomy using preoperative imaging.
- **Advantages**:
  1. Personalized fit for complex cases.
  2. Reduces surgical adjustment time.
- **Disadvantages**:
  1. Higher cost and longer preparation time.
  2. Requires advanced imaging and printing technology.

Cranial LOOP

CranioFix

CranioPlate

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see also Head Fixation

Selection Criteria for Cranial Fixation Devices

- **Patient Factors**:
  1. Age (e.g., resorbable devices for children).
  2. Skull thickness and anatomy.
  3. Risk of complications or comorbidities.
- **Surgical Considerations**:
  1. Type of craniotomy (e.g., standard, extended, or revision surgery).
  2. Expected stability requirements.
  3. Surgeon preference and familiarity with the device.
- **Material Properties**:
  1. Biocompatibility to avoid rejection or inflammation.
  2. Strength to maintain alignment during healing.
  3. Resorption characteristics, if applicable.
- **Cost and Availability**:
  1. Devices with fewer components, like clamp systems, may reduce costs.
  2. Access to specific technologies, such as 3D printing, may vary by location.

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Emerging Trends

- **Minimally Invasive Systems**: Devices like clamp-like systems (e.g., Cranial LOOP) focus on reducing trauma and improving patient comfort.
- **Smart Fixation Devices**: Integration of sensors to monitor healing and detect complications such as infection or displacement.
- **Sustainable Materials**: Development of eco-friendly and cost-effective resorbable materials.

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Conclusion

Cranial fixation devices are indispensable in modern neurosurgery, with a wide range of options tailored to different clinical scenarios. Advances in material science and device design, such as the introduction of clamp-like systems and 3D-printed solutions, continue to improve outcomes for patients. The choice of device should be guided by patient needs, surgical requirements, and available resources.
