INSTRUMENTATION IN NEUROSURGERY
(COAGULATORS, DRILLS, CUSA AND RETRACTORS)

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Coagulators

History

- Thermal energy for haemostasis,dates back to pharaonics,
- The earliest known surgical records - in papyrus documents from Egypt dated as early as 3000 B.C. called fire drill—a device which when turned rapidly produced heat along
- Hot iron
- Bovie and Cushing in 1920s
- Lasers in 1960s


Serratum.

Electrocautery

- variety of electrical waveforms
- a constant waveform, - This produces heat very rapidly, to vaporize or cut tissue.
- an intermittent waveform, produce less heat. Instead of tissue vaporization, a coagulum is produced.

Effect of temperature on cells

>40°C	Reversible cell damage
>49°C	**Denaturation** (irreversible cell damage)
>70°C	**Coagulation** (collagens convert to gelatin)
>100°C	**Desiccation** (cells dry as water vaporises, gelatin becomes 'sticky')
>200°C	**Carbonisation** , eschar formation (pathological 4th degree burns)

Monopolar Coagulators

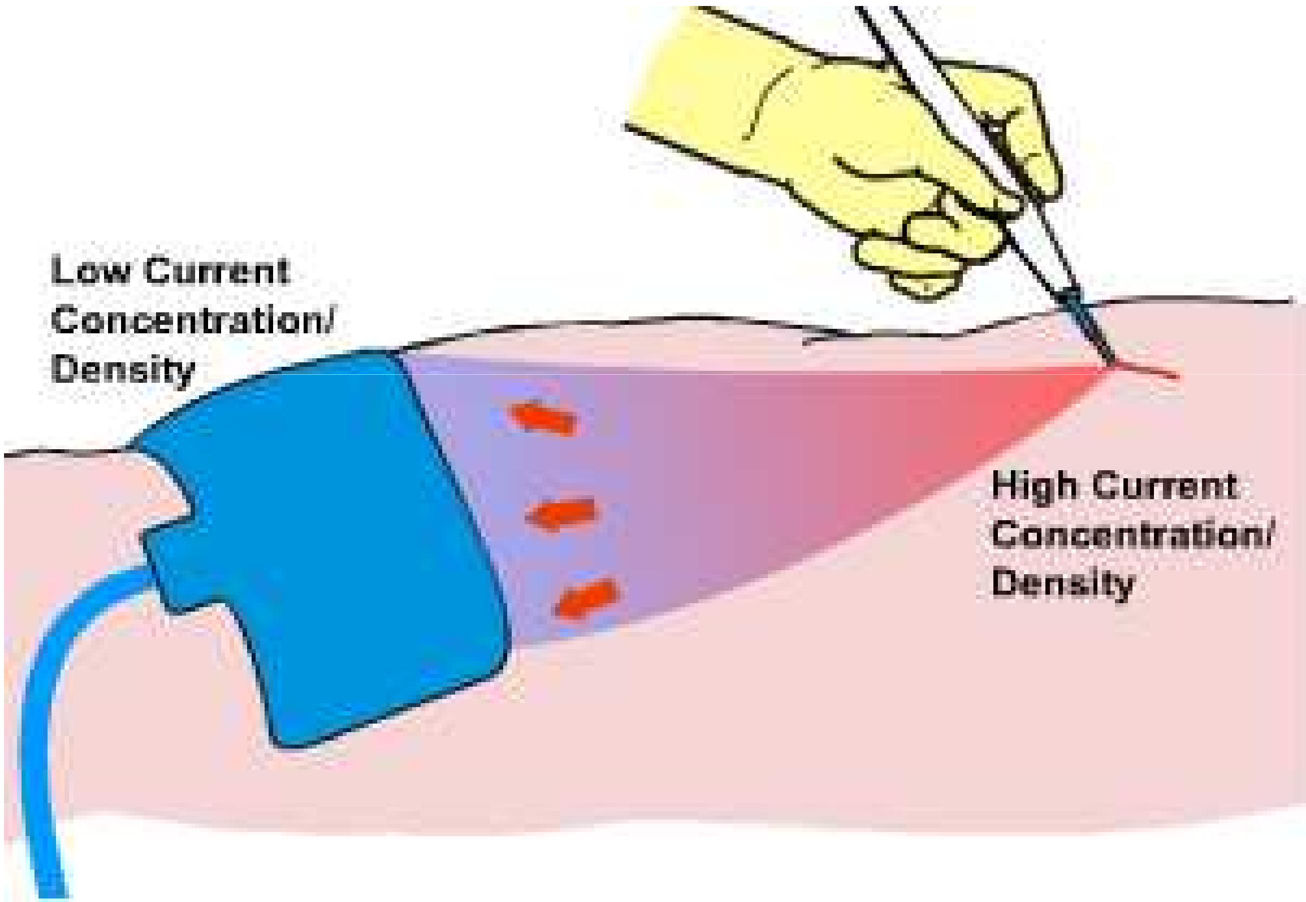
- Electrical energy in the range of 250000 to 2 million Hz
- Heating effect Depends upon the density of current
- Size of electrode should be as small as possible
- Fat,bone and air have low water content and hence high resistance
- Ground electrode must have a large area of contact to ensure low current density
- Healing is slower by 2 days,with wound having less tensile strength and larger scar (Vs scalpel cut)
- Increased susceptibility to wound infection

• The active electrode is in the wound.

• The patient return electrode is attached somewhere else on the patient. The function of the patient return electrode is to remove current from the patient safely.

$$\text{BURN} = \frac{\text{CURRENT} \times \text{TIME}}{\text{AREA}}$$

• The current must flow through the patient to the patient return electrode.


Low Current
Concentration/
Density
High Current
Concentration/
Density

Pad Site Location

Choose:	**Well vascularized muscle mass**
Avoid:	**Vascular insufficiency** **Irregular body contours** **Bony prominences**
Consider:	**Incision site/prep area** **Patient position** **Other equipment on patient**

Return Electrode Monitoring, actively monitor the amount of impedance at the patient/pad interface and deactivate system

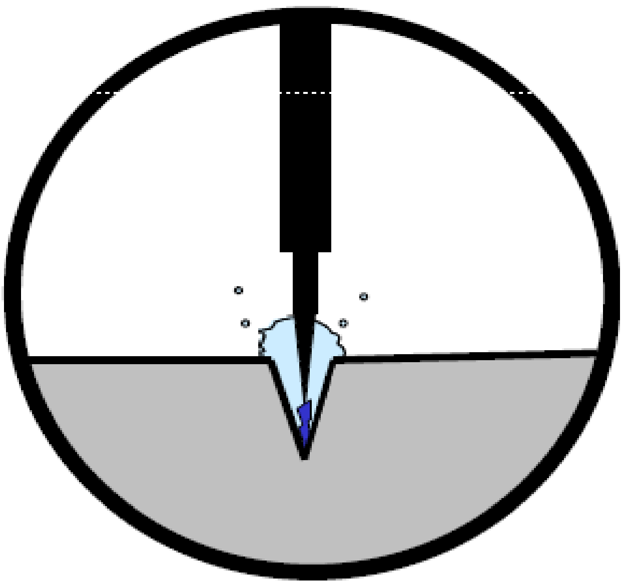
Modalities

cut	Coagulation	blend
Continuous wave	pulsed	Continuous,with resting period
yellow	blue	blue

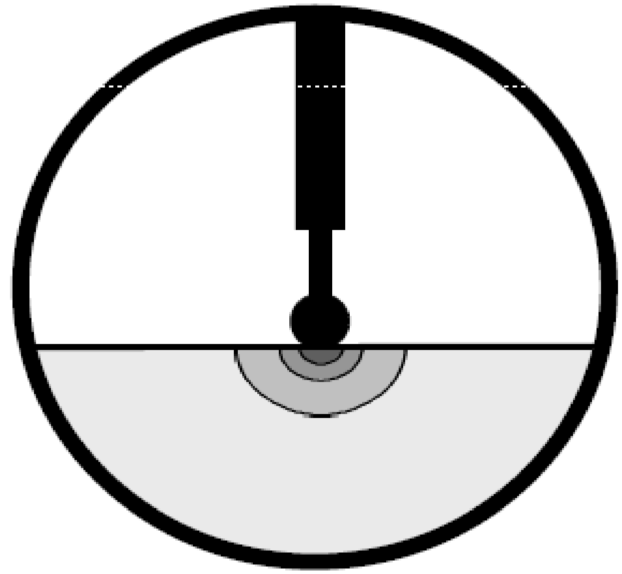
Coagulation → contact

Coagulation → spray

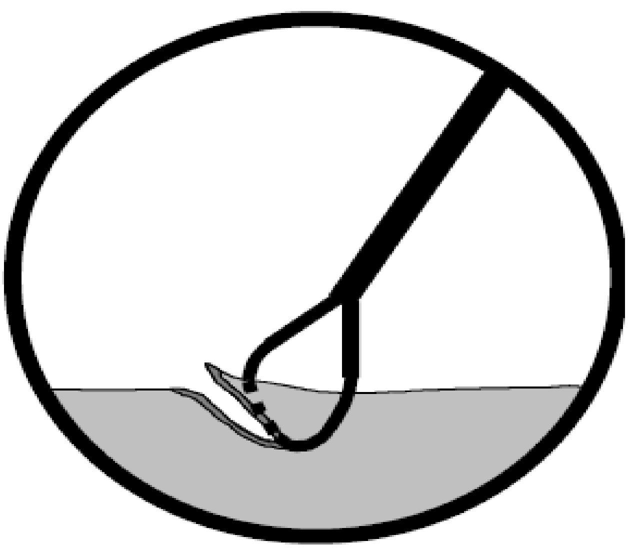
Endo cut: fractionated cutting under water



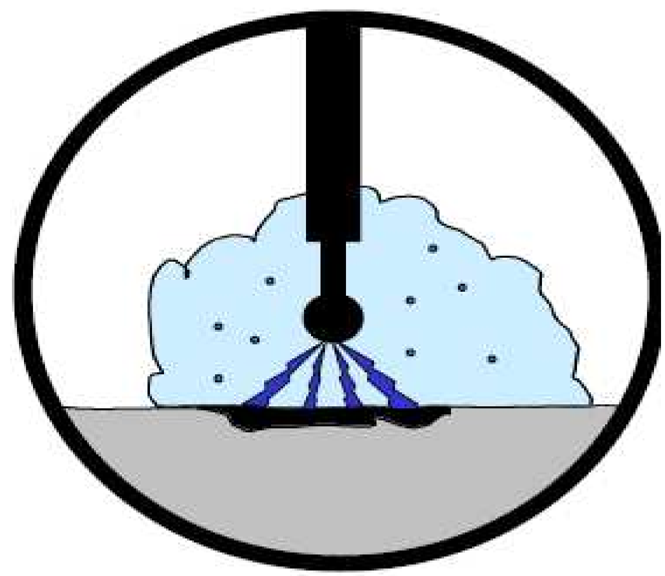
Cutting



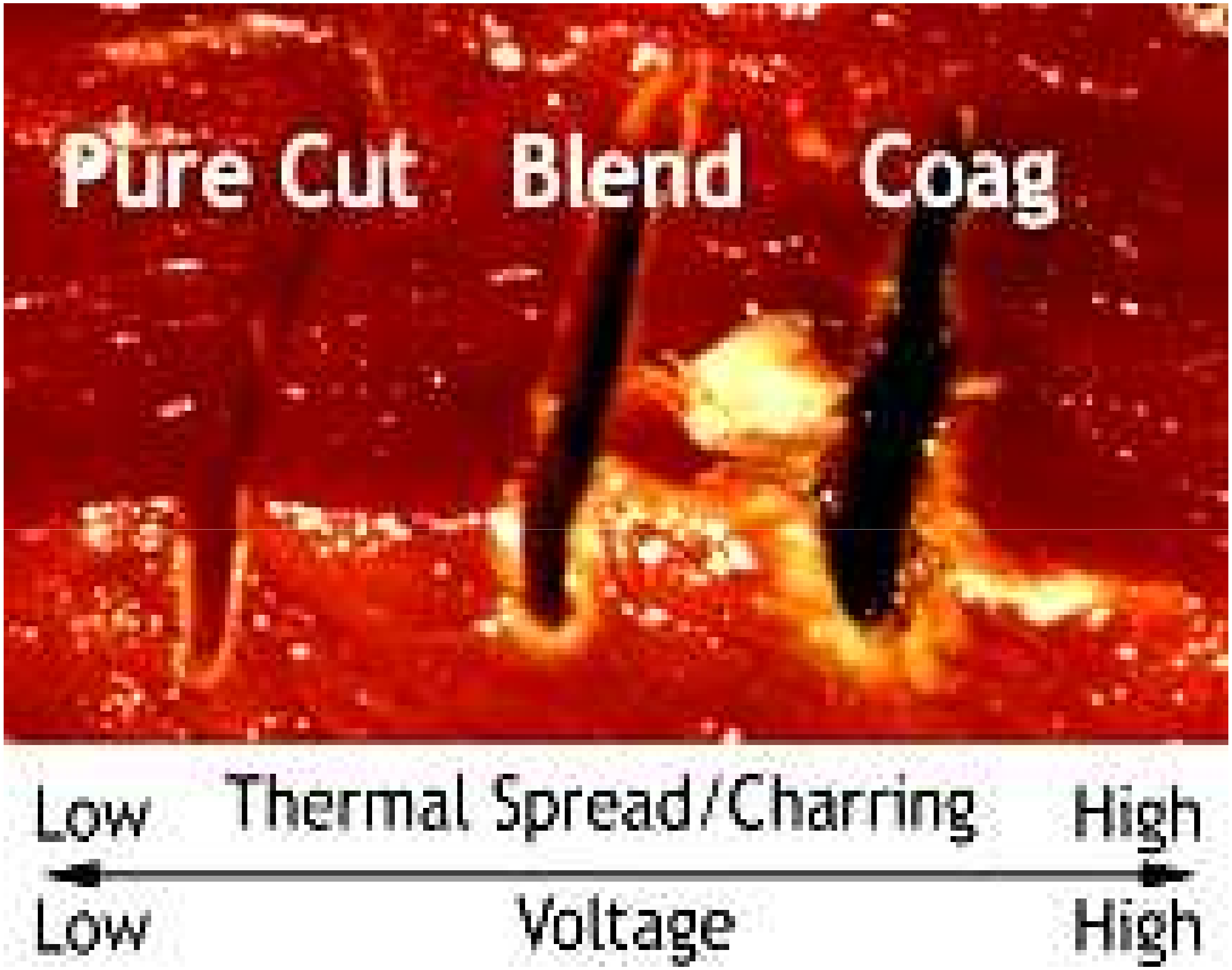
Contact Coagulation



Loop Excision



Spray Coagulation


Pure Cut
Blend
Coag
Low
Thermal Spread/Charring
High
Low
Voltage
High

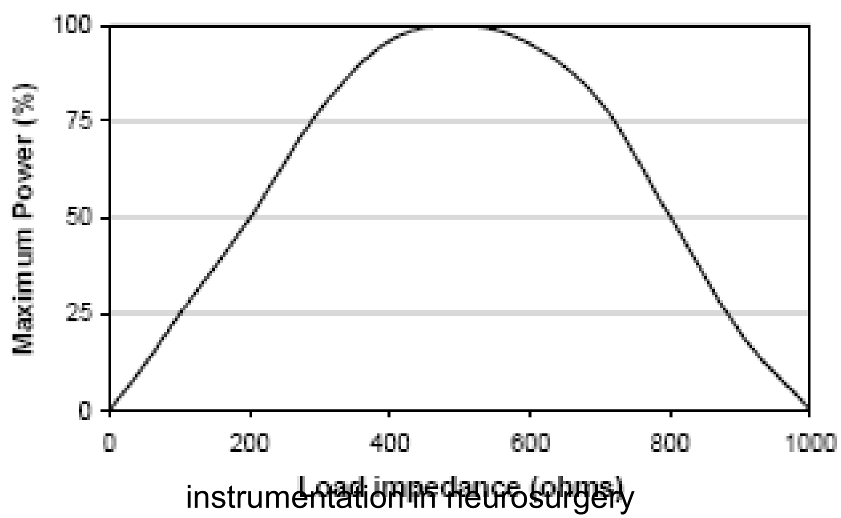
Variables Impacting Tissue Effect

- **Waveform**
- **Power Setting**
- **Size of Electrode,** The smaller the electrode, the higher the current concentration
- **Time**
- **Manipulation of Electrode**
- **Type of Tissue**
- **Eschar**

Safety measures

- **Start up self check**
- **Return electrode continuity monitor**
- **Contact quality monitoring**
- **Return current feedback monitor**
- **High frequency leakage monitor**
- **Earth leakage monitor**
- **Output error monitoring**
- **Smoke filtration**
- **Activation time limit alarm**
- **Do not activate the generator while the active electrode is touching or in close proximity to another metal object**

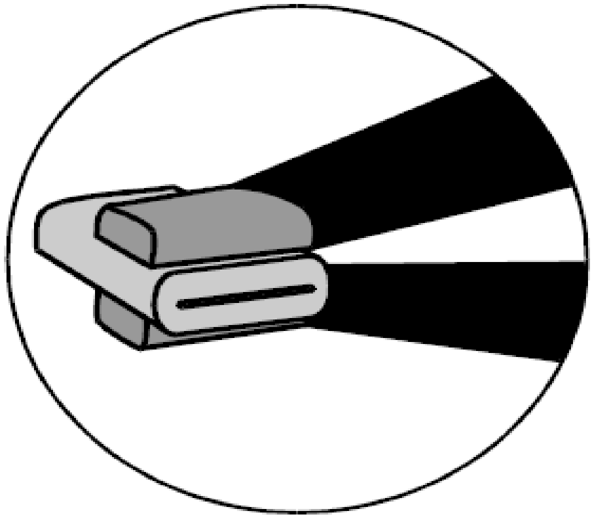
- Power output should be sufficient to achieve the desired surgical effect but should not be too high, Power requirements vary according to the desired surgical effect, the active electrode size and type



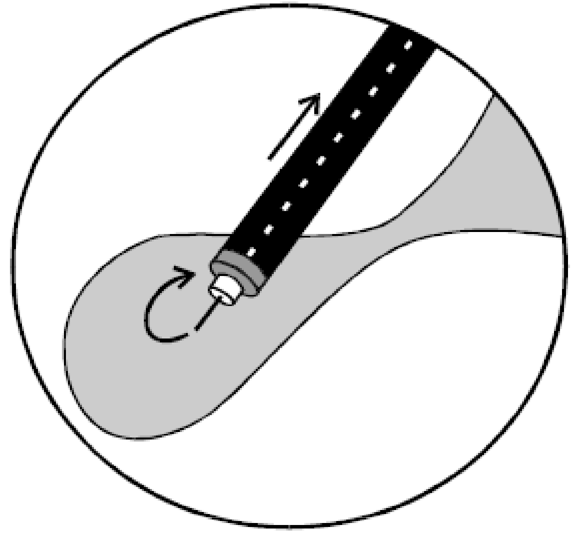
Bipolar Coagulators

- Greater precision and less damage to tissue
- Less power needed
- Current flows through one blade and out through other
- Only the tissue grasped is included in the electrical circuit
- More predictable and less stimulating muscles and nerves
- More effective for coagulating tissue under a layer of fluid
- Radionics vs malis bipolar instruments
  sensing device ,no need of irrigation,chances of inadequate coagulation

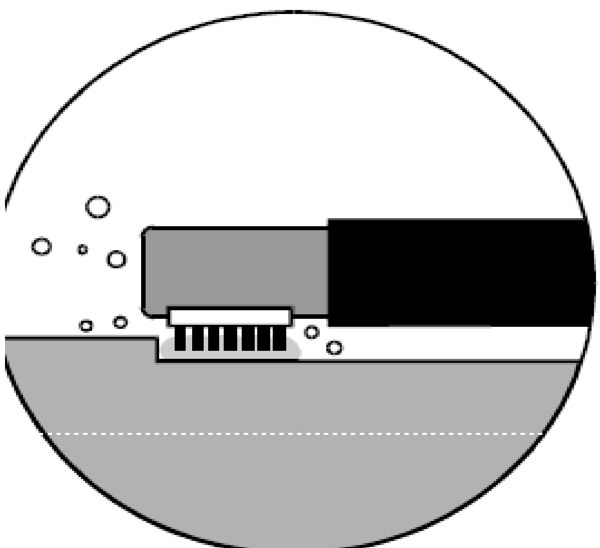
Modalities



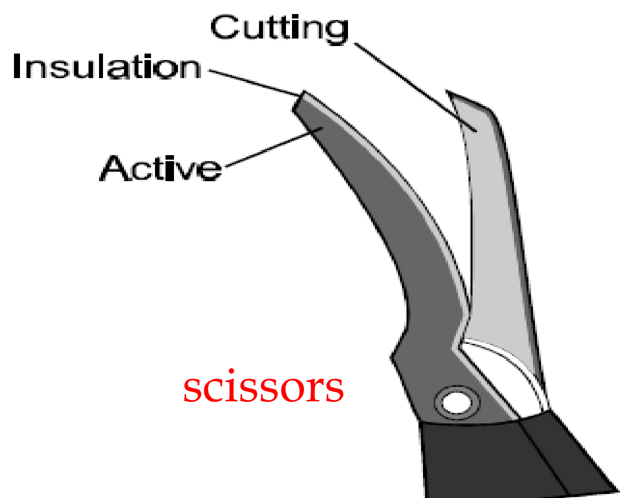
coagulation



cut



ablation



scissors

SS

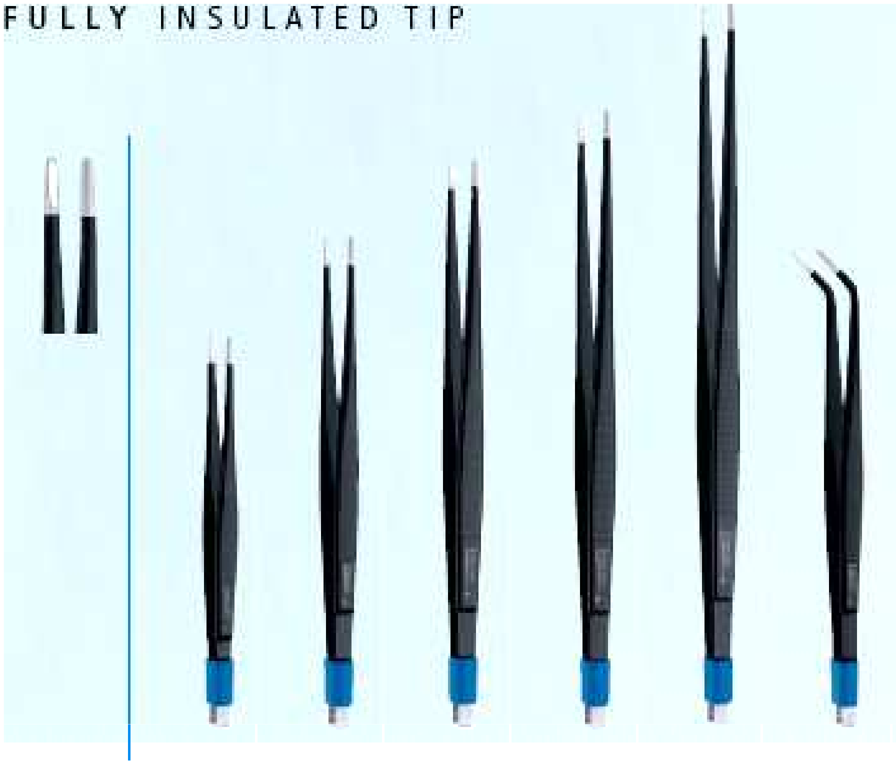
- Optimum distance between electodes
- Continuous irrigation with saline
- Charred tissue should be wiped off with moist clothes ,avoid blade to scrape

Tip diameter	use
1.5,2 mm	Large vessels and scalp bleeders,fascia ,muscles
.7-1mm	Dura and brain surface
.5 mm	Tissue close to blood vessels,nerves,and brainstem

Shaft length	
8cm	Brain surface to depth of 2 cm
9.5 cm	Deeper regions
10 cm	TNTS,posterir third ventricle

	micro	macro
Power range	0.1 – 9.9 watts	1-50 watts
adjustability	0.1 watts	1 watt
	Precise point coagulation	Universal use

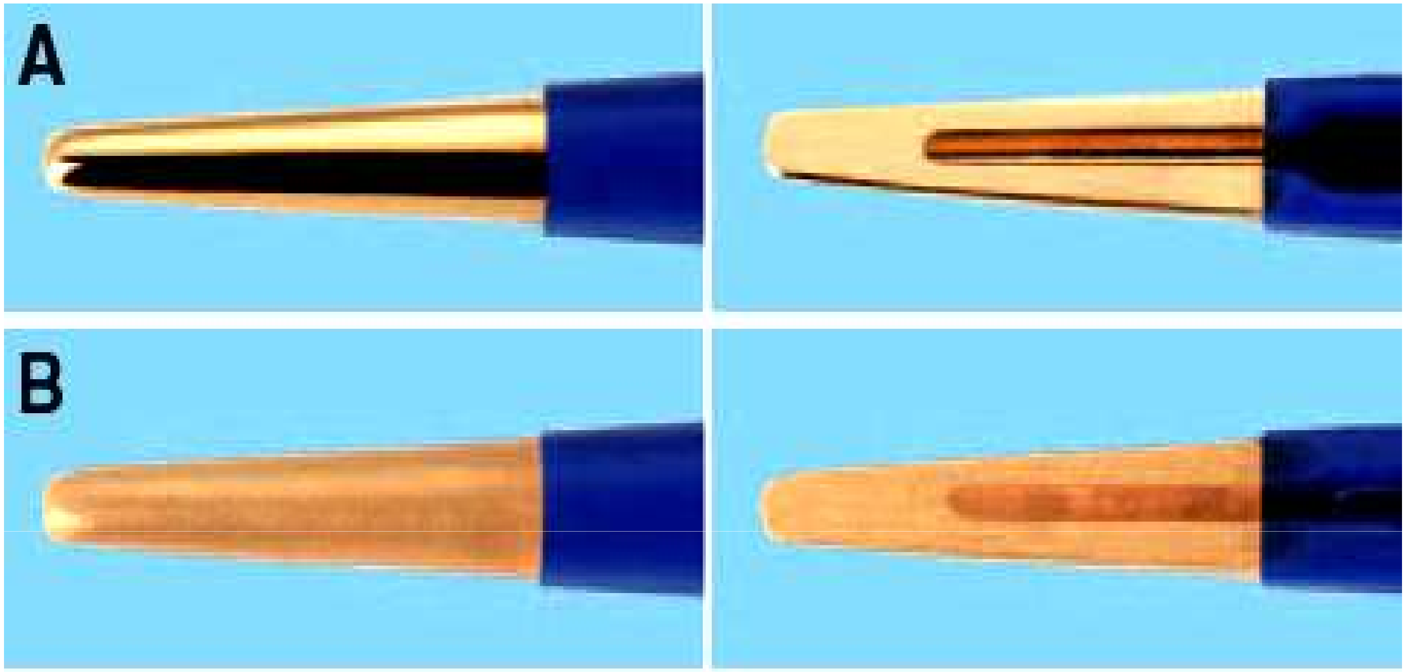
- Shafts of different length available
- Self irrigating forceps,pre irrigation and post irrigation function
- Jet irrigation systems in haematomas
- Transistorized coagulator system,equipped with themocontrole system(sugita and tsugane)
- Ohta etal,irrigation on when forceps is close
- PTFE coated forceps

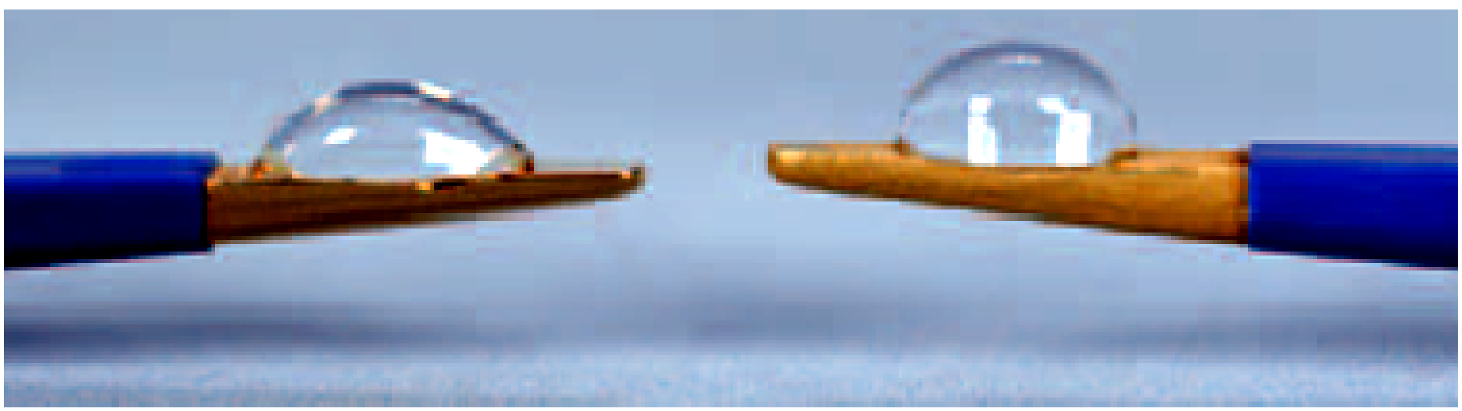

FULLY INSULATED TIP


PARTIALLY INSULATED TIP

Bipolar forceps with jet irrigation system

PTFE coated





Complications

- Formation of coagulum
- Adherence of the blood vessel to the tip of the forceps
- Penetration of aneurysm
- Undesirable regional tisssue damage due to grounding of current through the body

General principles

- Current flow should not be started till the desired bleeder is reached
- Current setting should be reduced when changing to fine tipped forceps
- Coagulation should be done in a small pool of water
- When irrigated it should not be flooded
- When using on a vessel forceps should be pulsated
- Current should be set as low as possible
- Should be cleaned immediately after use

Argon-Enhanced Coagulation & Cut

- **Decreased smoke, odor**
- **Noncontact in coagulation mode**
- **Decreased blood loss, rebleeding**
- **Decreased tissue damage**
- **Flexible eschar**

Harmonic scalpel

- leading ultrasonic cutting and coagulation surgical device
- using lower temperatures than those used by electro surgery or lasers
- vessels are coapted (tamponaded) and sealed by a protein coagulum
- Coagulation occurs by means of protein denaturation when the blade couples with protein   denaturs to form a coagulum that seals small coapted vessels

- control of harmonic Scalpels coagulation rate & cutting speed depends on time & force applied to the tissue by the end effector.

- The Harmonic Scalpel uses ultrasonic technology, & energy that allows both cutting & coagulation at the point of impact.

- As compared to electro surgery

  1) fewer instrument exchanges are needed

  2) less tissue charring and desiccation occur

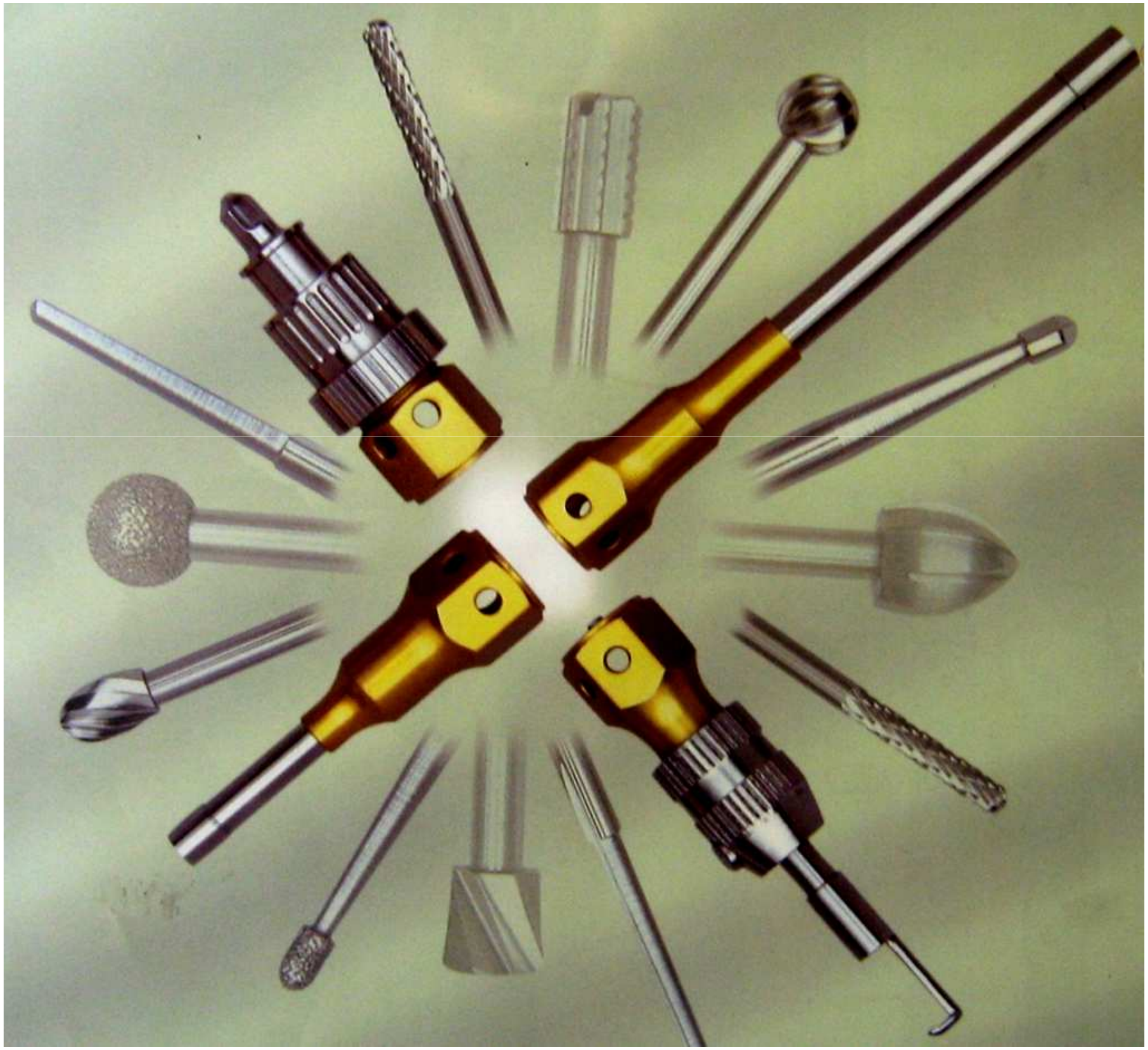
  3) visibility in the surgical field is improved.


The harmonic scalpel uses ultrasonic energy to both cut tissue and coagulate blood vessels
[redacted]

Laser coagulators

- Types :
  - CO_2 laser,
  - Nd : YAG Laser,
  - Argon Laser,
  - KTP laser
- Principle : Photocoagulation
- Explosive tissue vapourisation
- Coagulation,vapourization,haemostasis,Cutting

DRILLS IN NEUROSURGERY



- Development of early tools → trephination to latest motor powered microdrills

- Records of neurosurgery from 3000 BC shows
  1st evidence of trephination
  hand operated drill in dentistry- 100 AD

- First powered instrument devised by George f. green, English dentist in 1869

- Sir Heneage Ogilve 1st air powered drill & osteotome

- Robert m hall forest c barber devoloped modern high speed drills

Pneumatc high speed drill system

System comprises of

1) Motors

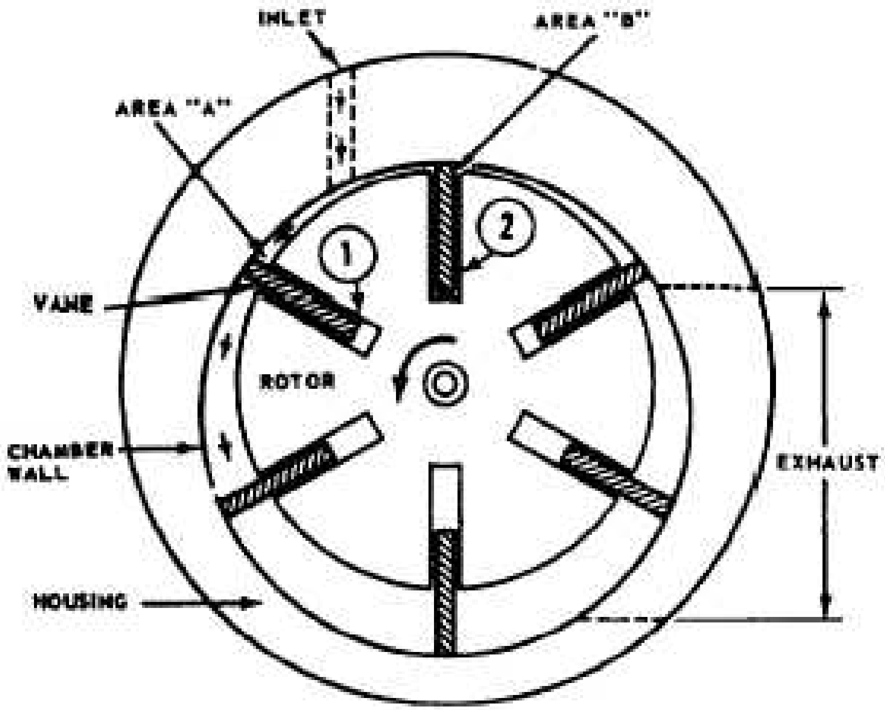
2) Pneumatic control unit with regulator & various connectors

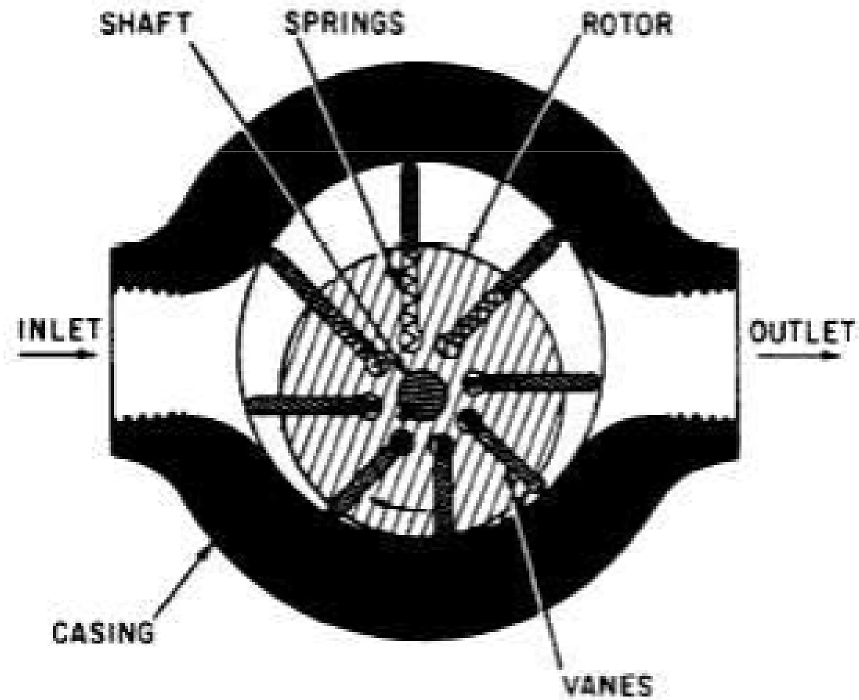
3) Various attachments & dissecting tools

4) Lubricant/diffuser

Mechanism

- Vane type is the hallmark
- Rotor spindle housed in rotor housing
- Vanes are incorporated on lengthwise slots on the rotor spindle
- Speed ranges from 65000 to 100000 rpm
- Speed more than 25000 – bone meltsaway easily
  - no tactile sensation


INLET
AREA "B"
AREA "A"
1
2
VANE
ROTOR
CHAMBER WALL
EXHAUST
HOUSING


SHAFT
SPRINGS
ROTOR
INLET
OUTLET
CASING
VANES

Advantages

- Great precision
- Hands are free for the control
- Time saving
- If used properly it is the safest, for both patients & surgeon

Instructions

- Stable body
- Microscope should be positioned in a comfortable operating position
- All loose materials should be removed from the field
- Hand piece should be of light weight & should be held in pen holding position

- Drilling underwater :

  1) It allows the neurosurgeon to visualize prospective structures through bone, which becomes semitransparent when adequately hydrated

  2) Underwater drilling protects key neuroanatomical structures from thermal injury

  3) Irrigation serves to constantly wash the head of the drill bit

- Visualizing critical structures through bone

- Drilling parallel to underlying structures

The movement of the drill bit should proceed along the axis of the underlying structure being exposed. the sigmoid, means a predominantly superior-inferior motion, whereas for the middle fossa dura, the motion is in ananterior-posterior plane.

- Drilled part should be in the form of a saucer rather than in the shape of cup

It provides the neurosurgeon with increased visualization

& working angles ,smaller potential space in which a

pseudomeningocele can develop & decreases the sharp

bony edge that may result in skin tightness and possible

wound breakdown.

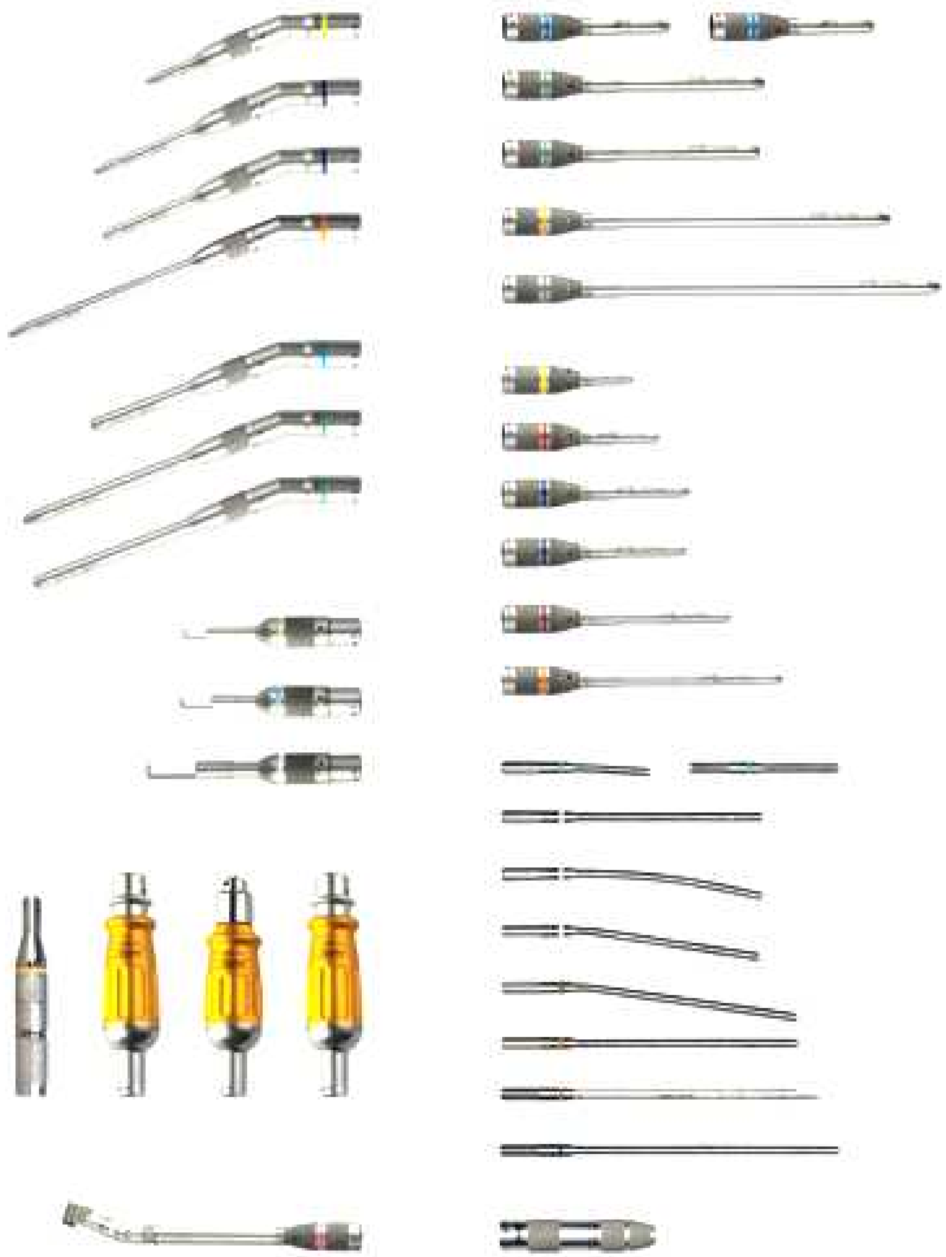
- Burr should always rotate away from the critical structures
- Choice of drill bit

  1) Cutting burrs work more efficiently when removing large amounts of bone

  2) Diamond burrs are used

  - when working close to, or potentially close to, critical neurovascular structures.
  - for hemostasis when used briefly without irrigation at a site of bleeding.

  3) The size of the drill to use the biggest one the working space safely allows



S t r I g h t

A n g l e d

Footed

1 Snap onto motor

2 Click in tool

3 Rotate to lock

Dissecting tools

Acorn, Cylinder Ball Tapered Match Head

Bone mill

Applications

- Craniotomy
- Correction of craniosynostosis,
- craniofacial anomalies
- Laminectomy,laminoplasty
- Foraminotomy
- removal of osteophytes,iliac crest grafting etc.
- Excision of odontoid in TOO
- Removal of ACP

Complications

- Direct penetrating injury
- Transmission of heat
- magnetic imaging metal artifacts
- Noise pollution
- Transmission of prion diseases

Electric Drill

- More powerful than pneumatic
- Improved overall system weight and balance - cable lighter, more flexible than pneumatic hose
- Reversible direction
- Cable design prevents incorrect connection and assembly

RETRACTORS

Adequate exposure of the target organ represents a laudable prerequisite of every successful operation.

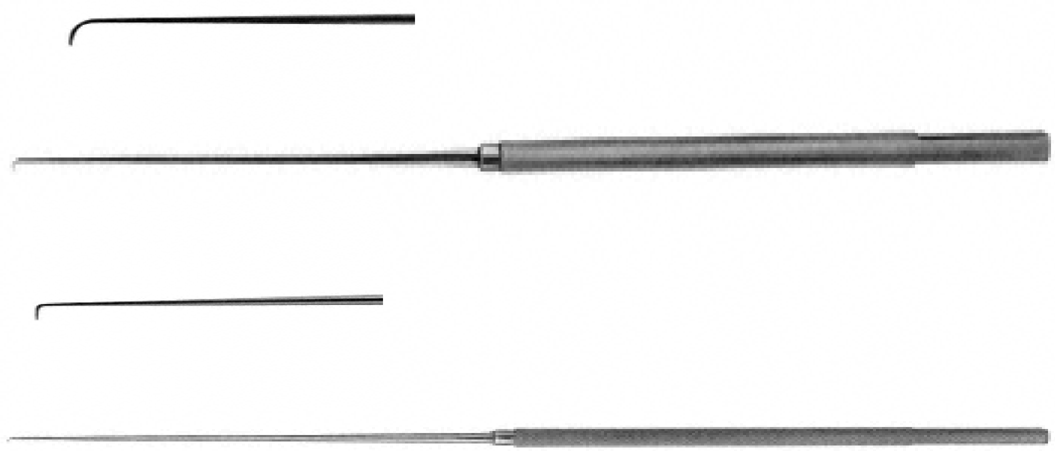
- Hand held

- Self retaining

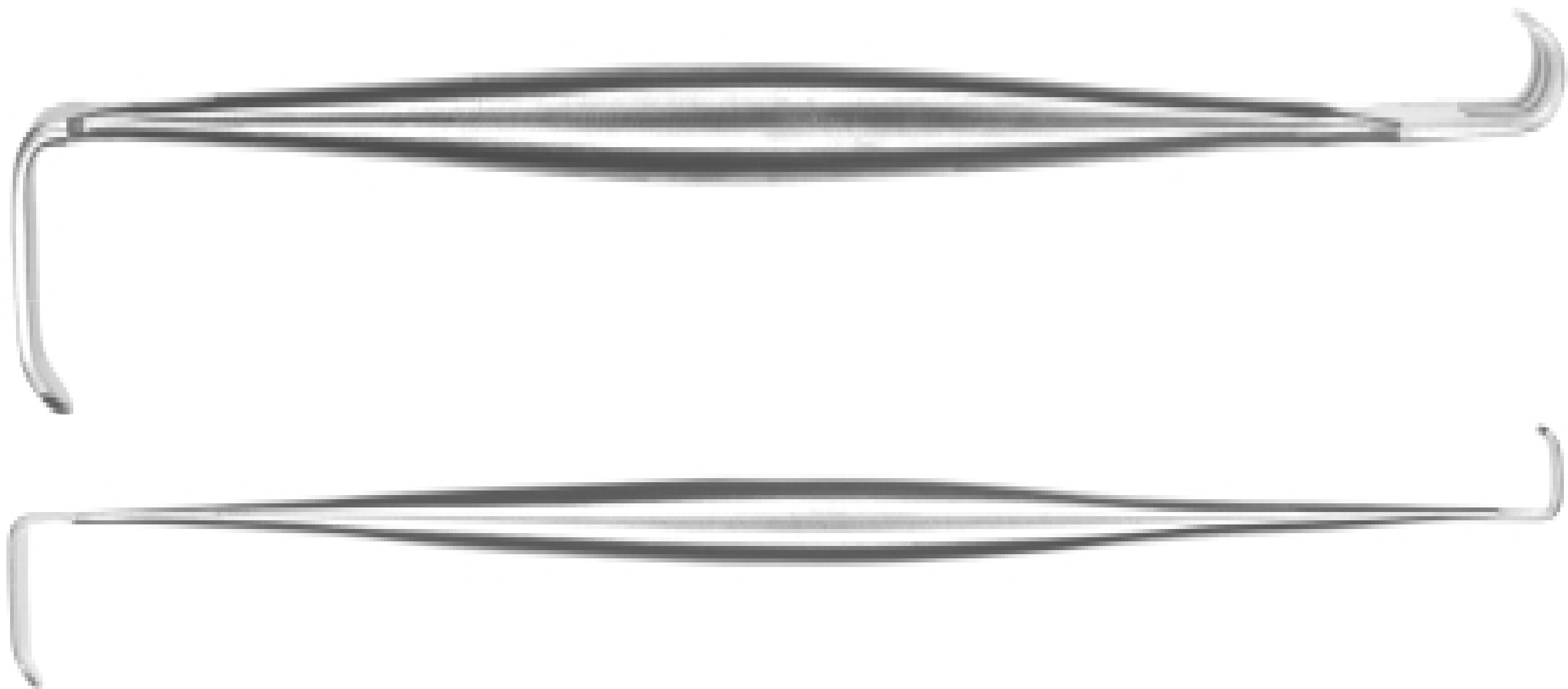
Hand held retractors

- **Disadvantages:**

- Slipping from the desired position
- Excessive retracion
- Obscuring vision and light
- Inability to maintain in same position for long time



Dural Retractors



Self retaining retractors

- Mechanical retractor mounts for neurosurgery,in 1930s
- Earliest skull mounted system (Demartel,Malis, Heifetz,edinburgh,hamby etc.)
  - mounted on burrhole,craniotomy edge
    - Inadequate bone strength,obscuration of the field
- Soft tissue/muscle mounted and pillar and post devices (house and urban,weitlaner)
  - less stable, less flexible

- Skull mounted flexbar devices (Dohn and Carton,Apfelbaum) especially useful in Posterior fossa surgery

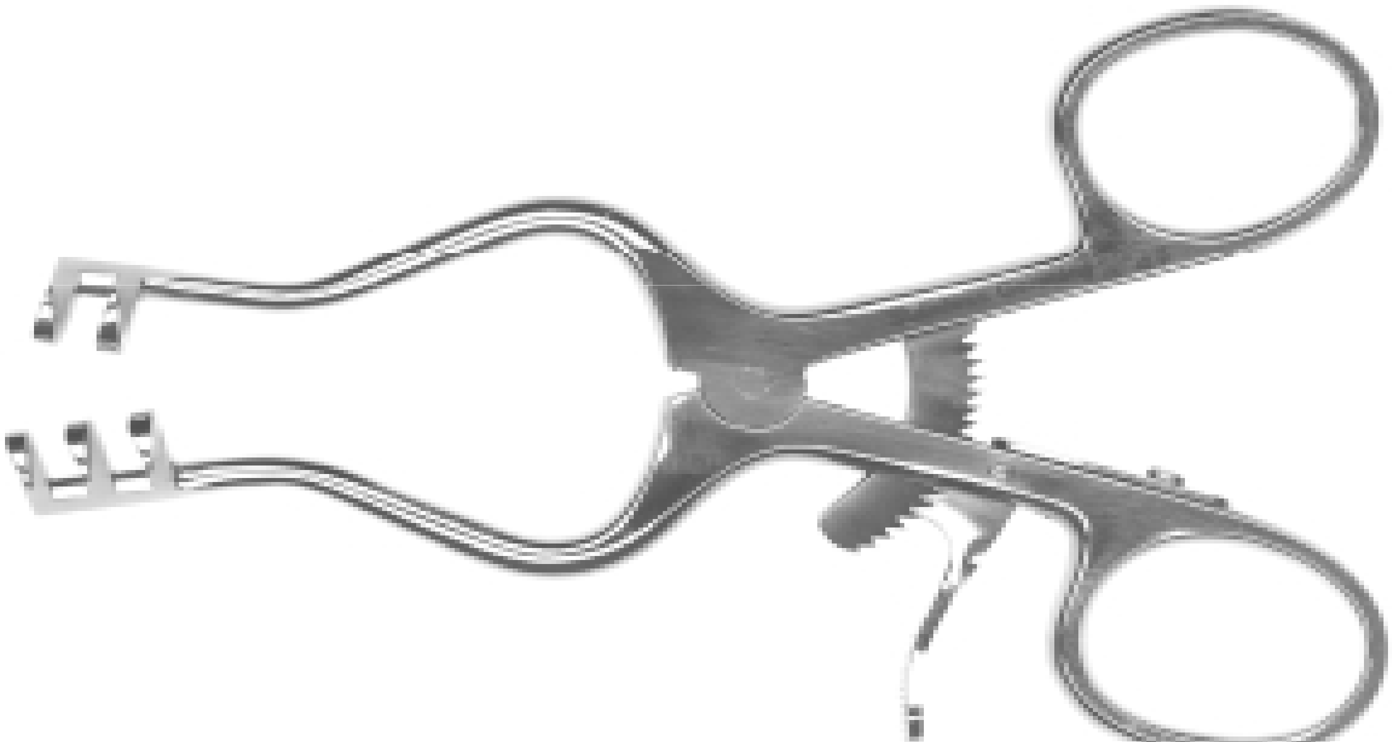
- Leyla retractor,Yasar gill
  adjustment difficulties,extreme length of the flexible arms

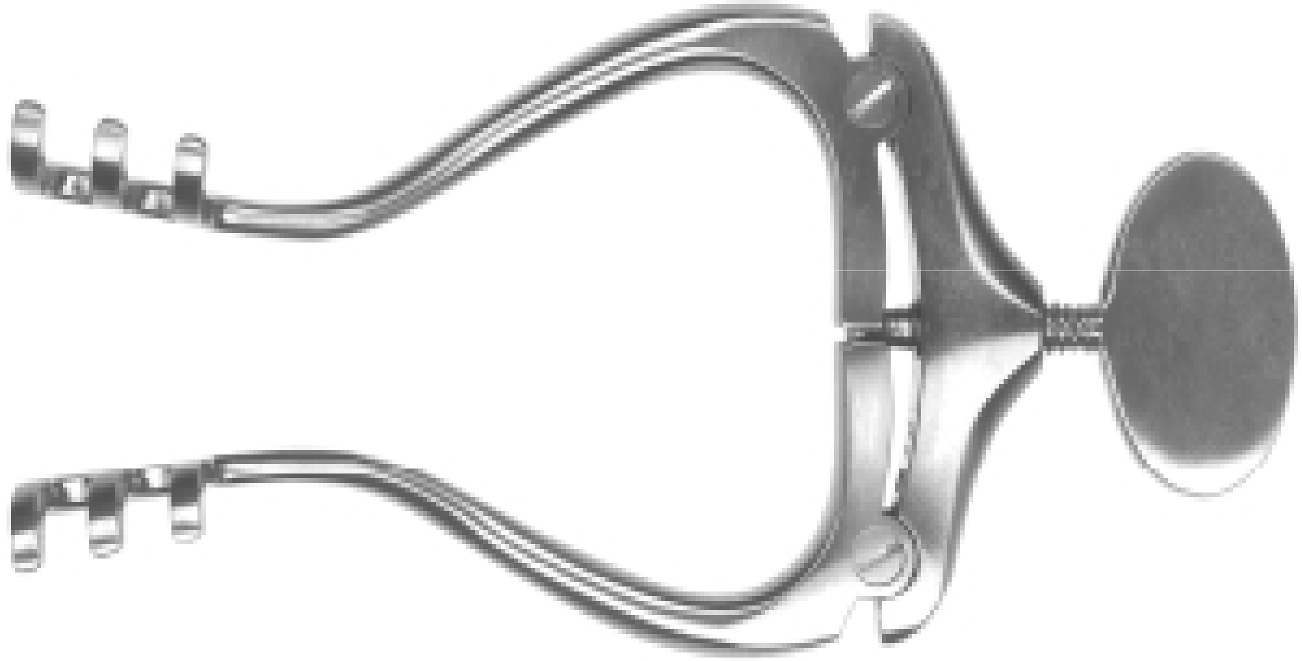
- Table mounted flexbar devices
  modification by yasargill and fox
  Kanshepolsky,U shaped bar

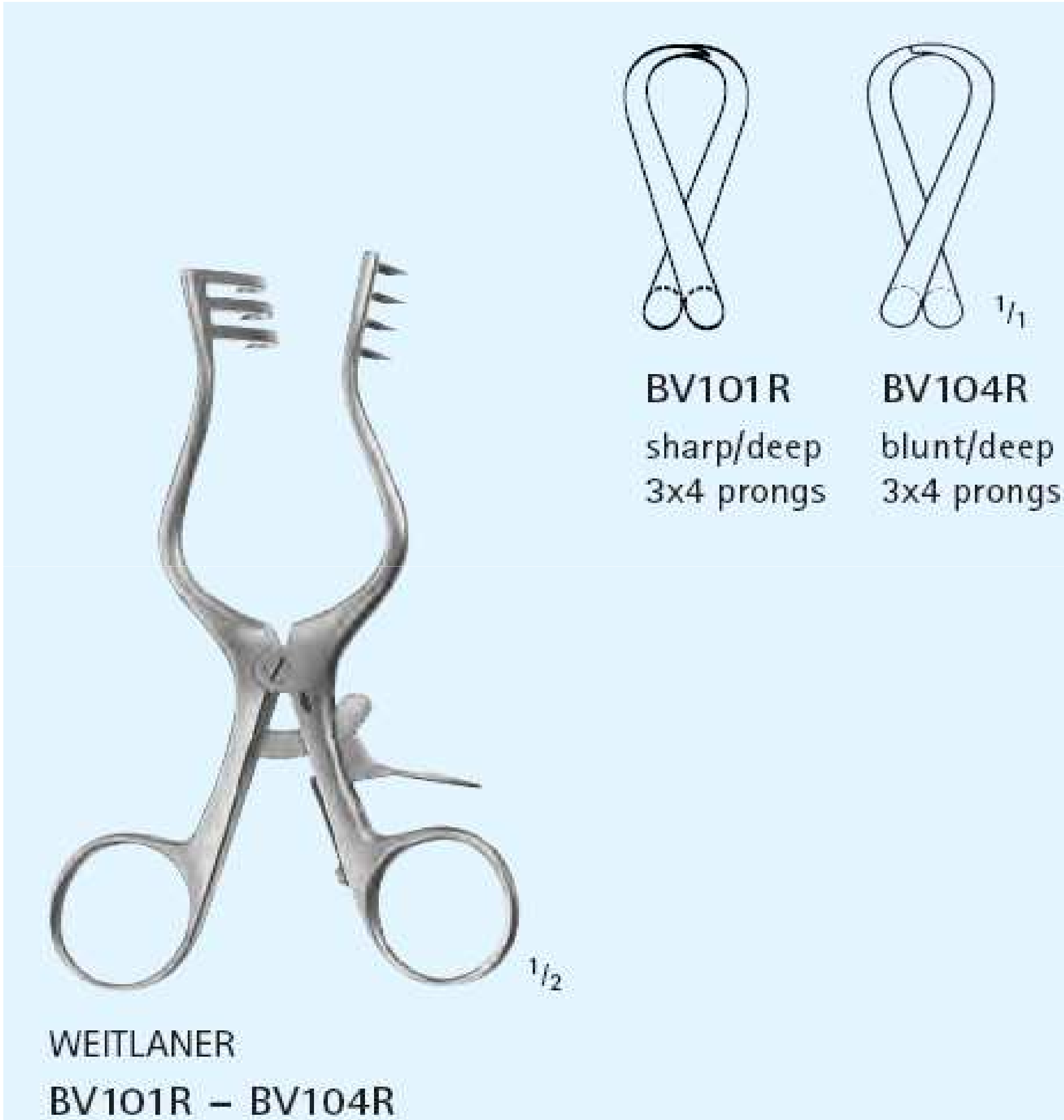
* head or retractor movement independent of each other

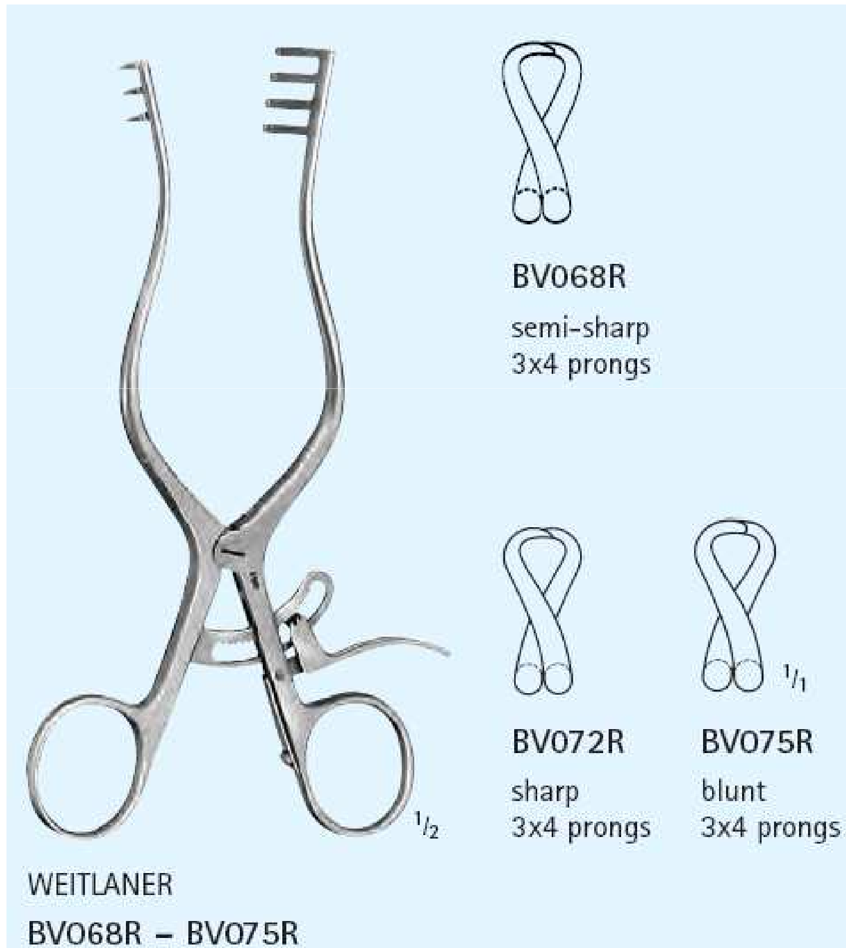
- Headrest mounted flexbar system
  sugita,Greenberg,
- Fukushima and Sano ,4 arms on clamp secured to mayfield headrest

Self Retaining Retractors



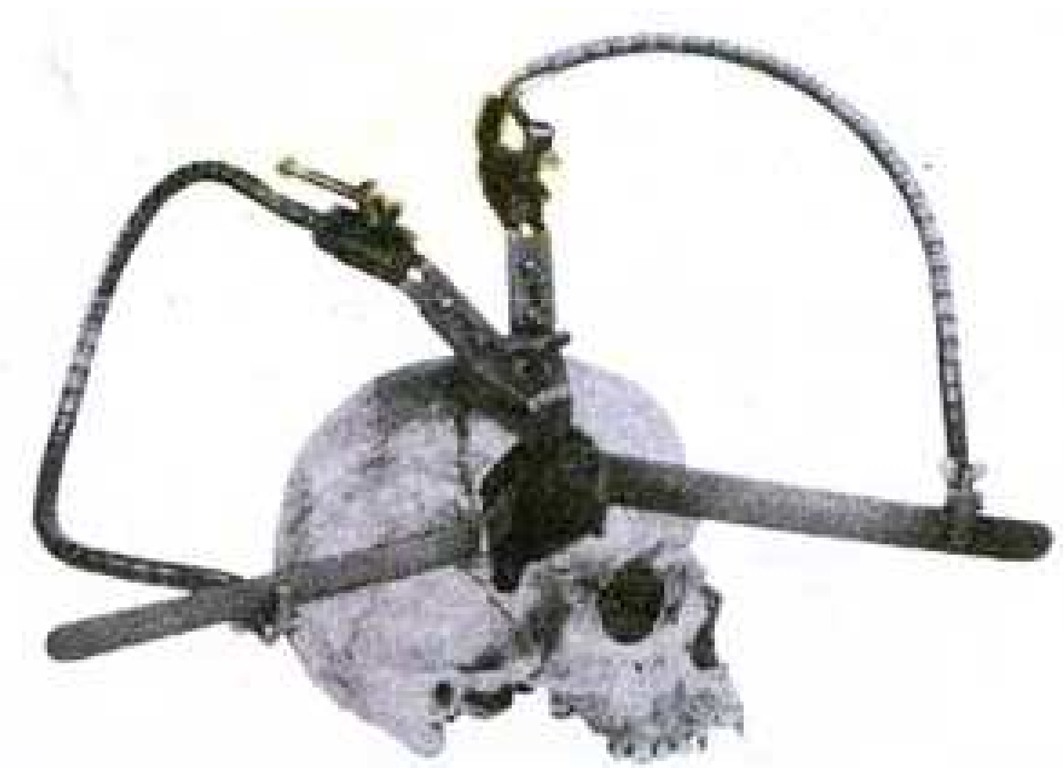



BV101R
sharp/deep
3x4 prongs
BV104R
blunt/deep
3x4 prongs
1/1
1/2
WEITLANER
BV101R – BV104R



BV068R
semi-sharp
3x4 prongs
BV072R
sharp
3x4 prongs
BV075R
blunt
3x4 prongs
WEITLANER
BV068R – BV075R

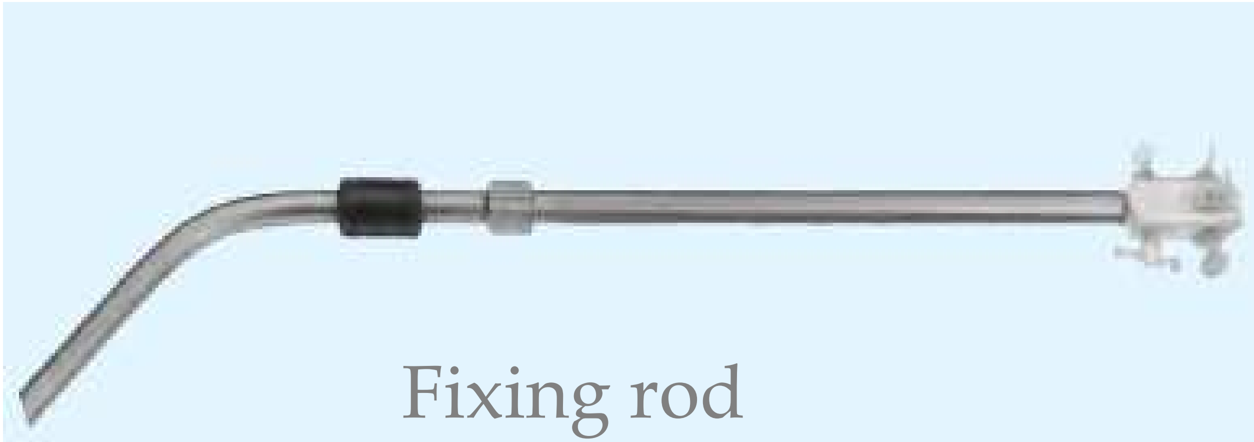
Skull mounted Retractor System



Leyla self retaining retractor

- Yasargil
- Self retaining,no assistance needed
- Uniform hoding,no pressre irritations
- Upto 5 flexible arms can be used simultaneosly
- No obstruction to operative vision
- No restriction of operating area – critical when using microscope

Ball and socket joint for fixing holding rod to operating table



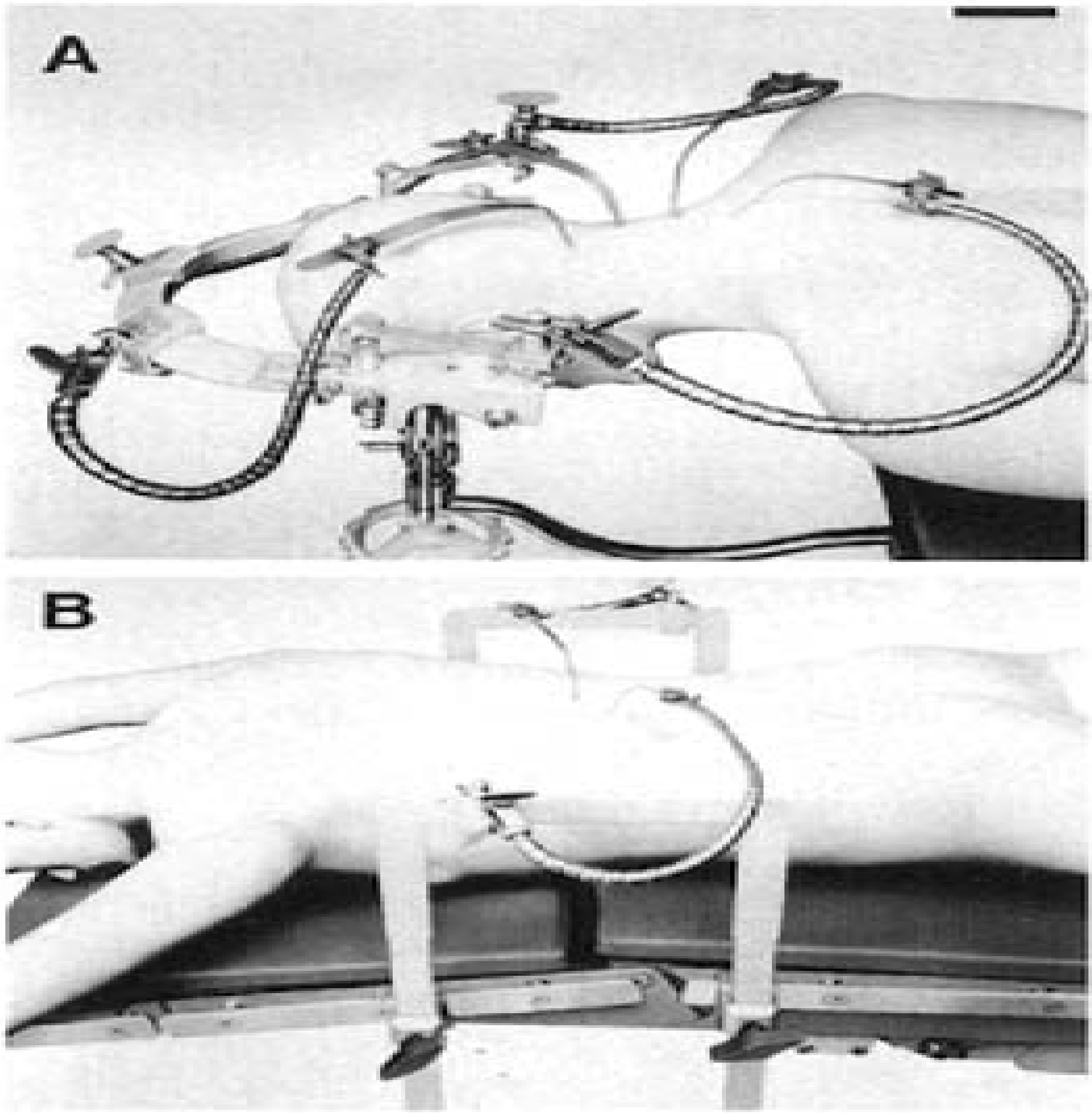
Fixing rod

coupler


FF273R or FF274R necessary
YASARGIL
Flexible arm


spatula

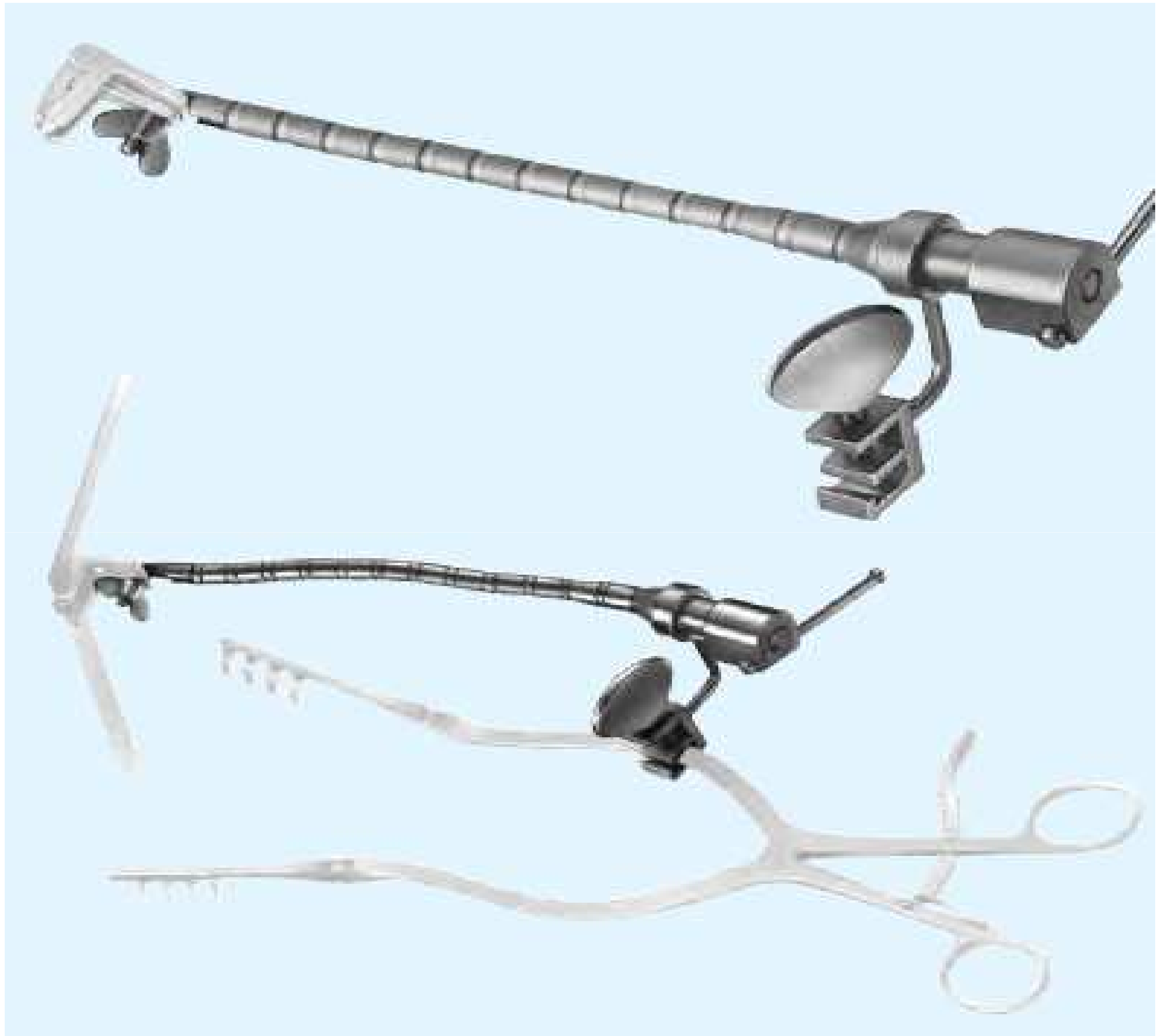
S u g i t a



NEW JERSEY Retractor system

Advantages:
• unique fixation clamp allows unlimited positioning of the retractor arm along the body of the retractor

• Attaches to virtually all self-retaining retractors
• Two retractor blade supports are available ,allowing the use of both flat and round shaft retractor blades
• Provide improved exposure on Posterior Fossa Craniotomies
• Excellent for nerve root retraction during laminectomy procedures



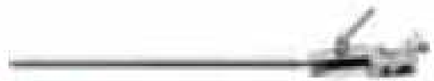
BUDDE Halo Retractor System

Greenberg Retractor System

50-1507 GREENBERG Primary Bar attaches to skull clamp
GREENBERG Retractor Kit (50-1500) is supplied with two primary bars.

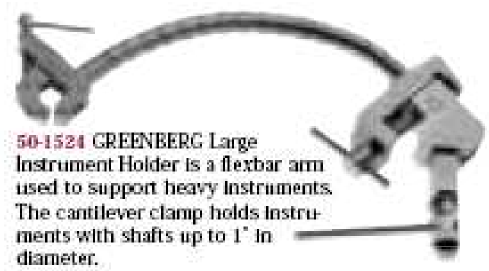
50-1509 GREENBERG Long Retractor Arm attaches to floating secondary bars. GREENBERG Retractor Kit (50-1500) is supplied with four long retractor arms.

50-1513 GREENBERG Pattie Tray attaches to long or shortarm (50-1509 or 50-1511)



50-1516 GREENBERG Floating Secondary Bar Attaches to Primary Bar (50-1506) or Secondary Bar (50-1508) or Short Coupler (50-1522). Can also be mounted onto a flat metal edge of up to 1/2" thickness incorporates a universal joint enabling conical adjustment of angle.

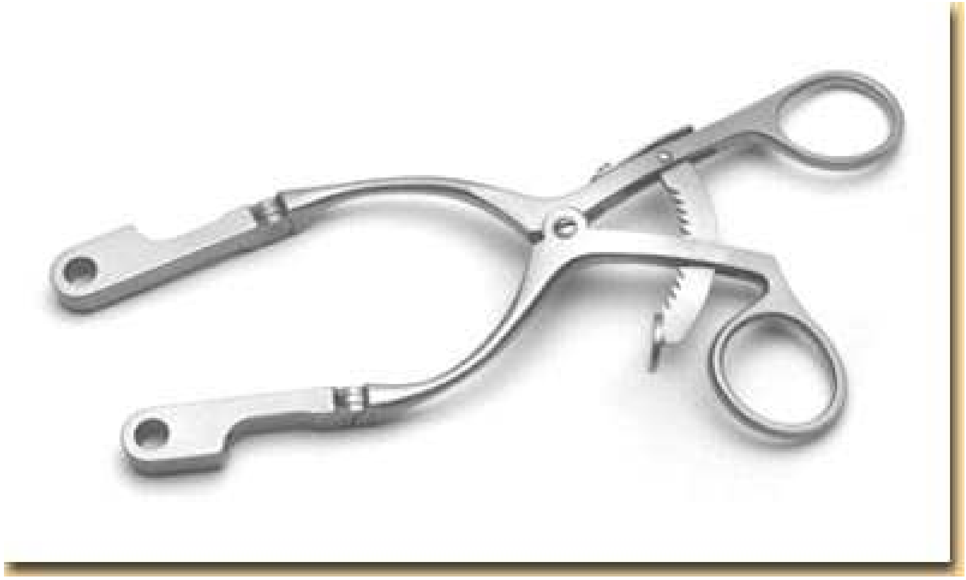
50-1522 GREENBERG Short Coupler should be used to mount the GREENBERG Handrest(50-1512) to the floating secondary at Level I.



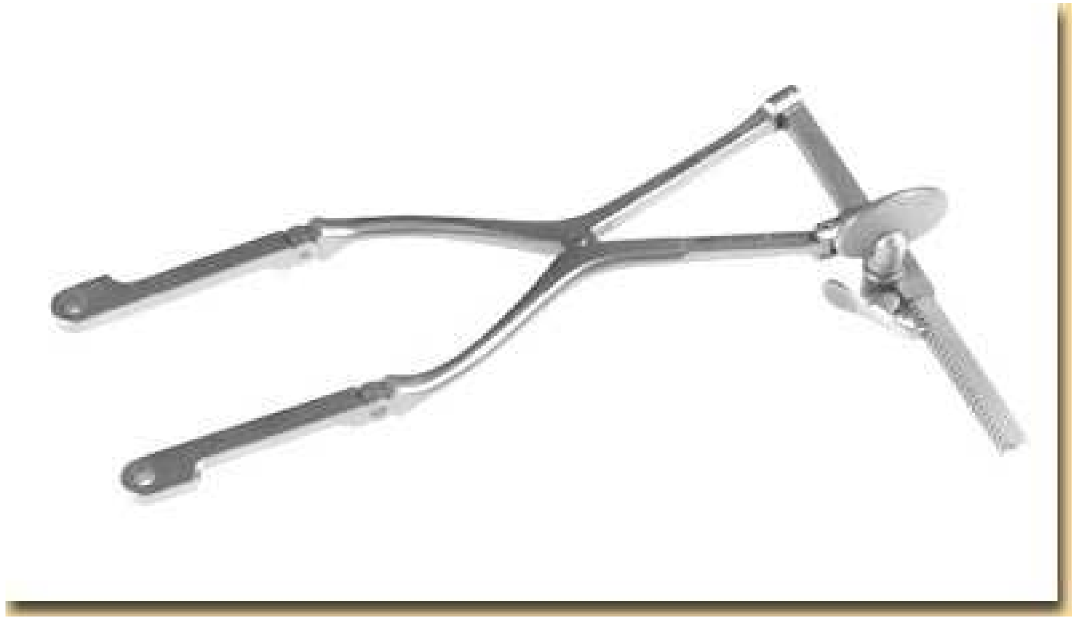
50-1524 GREENBERG Large Instrument Holder is a flexbar arm used to support heavy instruments. The cantilever clamp holds instruments with shafts up to 1" in diameter.

50-1525 GREENBERG Universal Retractor System
X-large Instrument Holder holds instruments up to 2" in diameter.

C l o w a r d



C l o w a r d



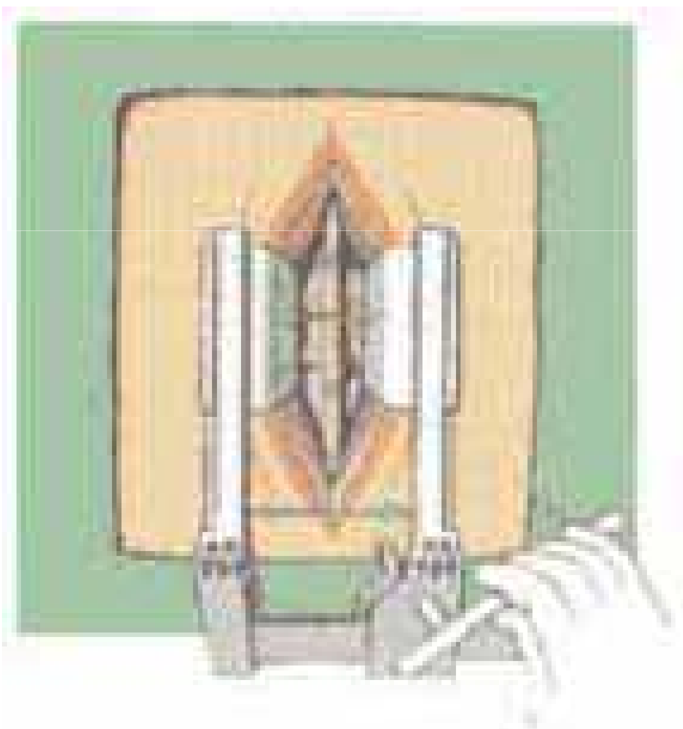
Lumbr retraction handle

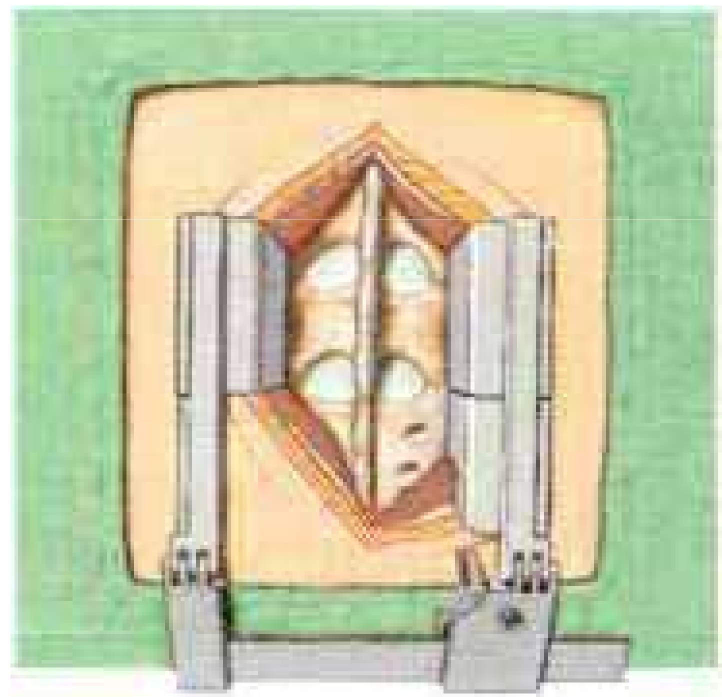
Caspar retractors


Retractors
BW048R
CCR counter retractor,
preferably used for
longitudinal retraction
BW049R
CCR basic cervical retractor,
preferably used for
transverse retraction,
double hinge,
tiltable butterfly screw
BW047R
CCR basic counter retractor,
preferably used for
longitudinal retraction,
double hinge
BW010R
Handle
for blades
with side load
attachment
BW011P
Depth gauge
to determine
the appropriated
blade length

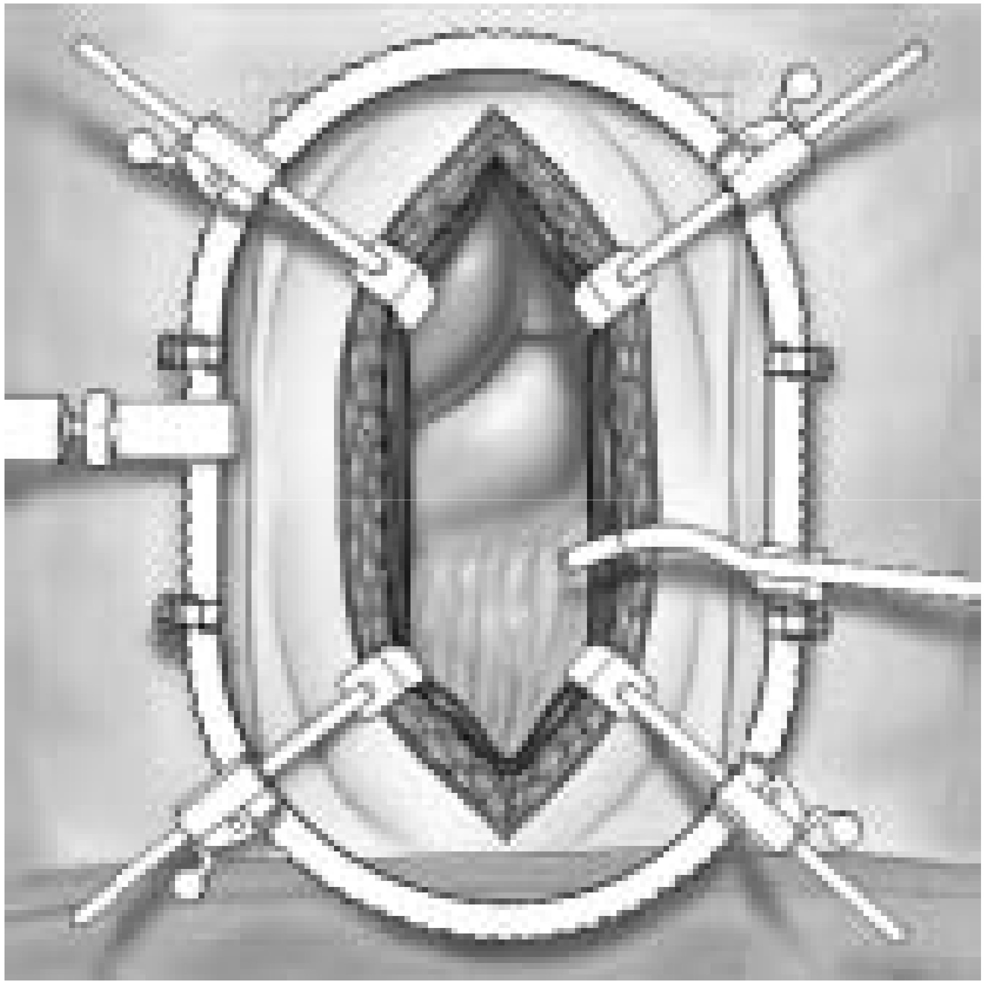
Crank frame Spinal Retractor System

Designed for posterior thoracolumbar surgeries



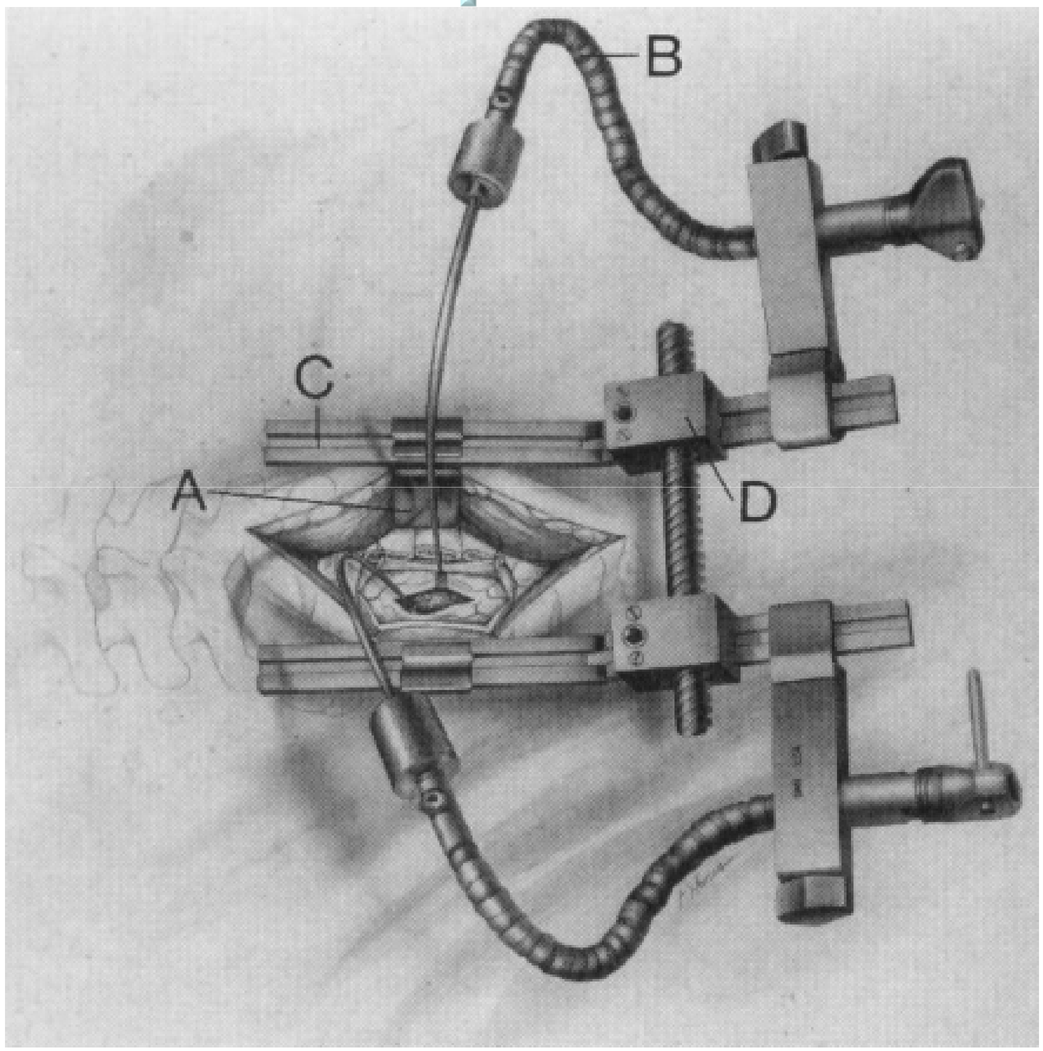


The BOOKWALTER Retractor.



Provides simple, multi-directional exposure for a broad range of surgical procedures

Tew Cranial/Spinal Retractor



* Capacity to simultaneously manipulate the spinal cord

Brain Retraction Injury

- The incidence of contusion or infarction from overzealous brain retraction is probably 10% in cranial base procedures and 5% in intracranial aneurysm procedures.
- Brain retraction injury is caused by focal pressure (the retractor blade) on the brain leading to

  1) Reduction or cessation of local perfusion

Retraction Injury

- Depends upon

1.shape

2. number of the retractors
3. the pressure
4. duration of the retraction

- The retraction pressures used are usually in the range of 20 to 40 mm Hg
- use of two small retractor blades may provide exposure equivalent to one large blade with a lower retraction pressure

Retraction

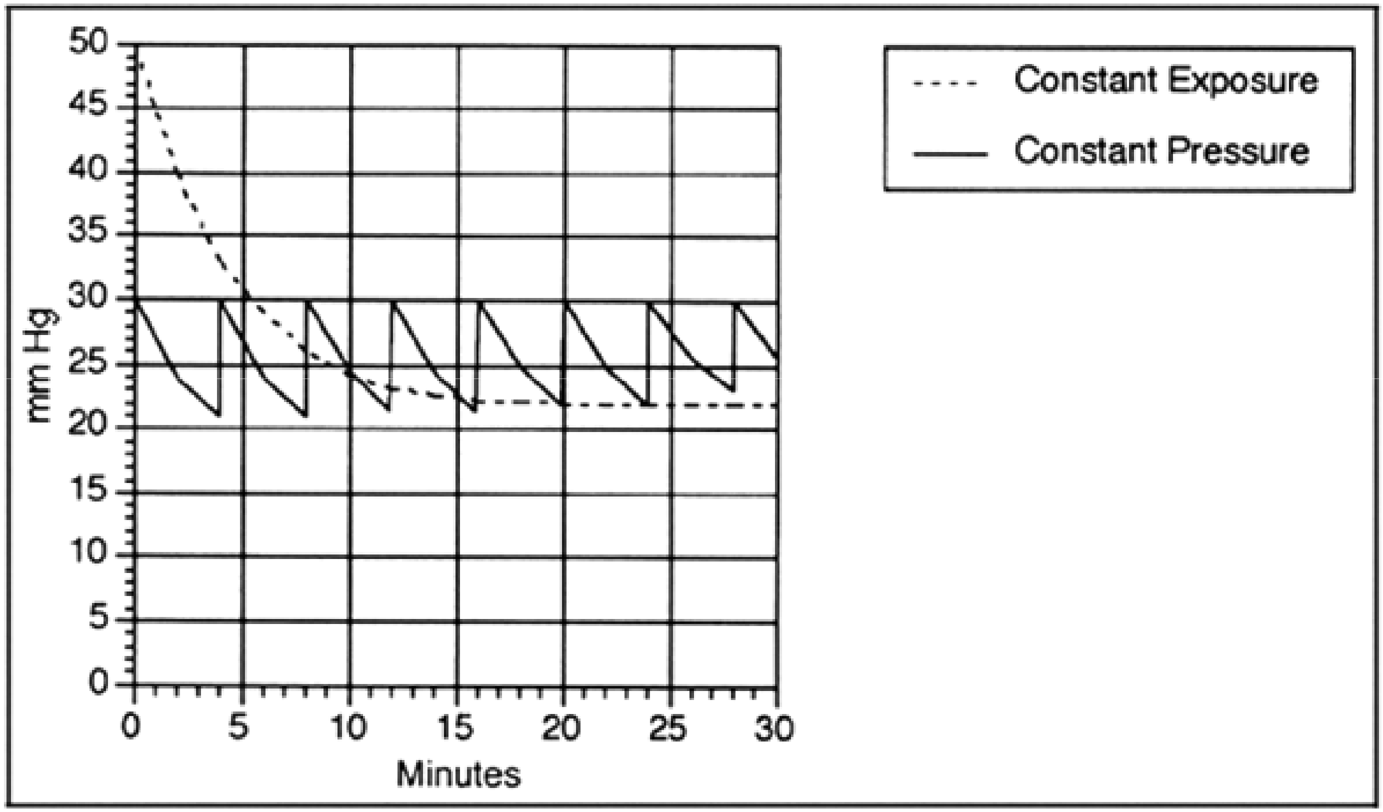
Constant pressure

retraction involves readjusting the retractor blade as necessary to keep the pressure constant ,

this type of retraction is naturally suited to retraction pressure monitoring

Constant exposure

retraction entails setting the retractor blade once without further adjustment. The brain is allowed to adjust over time to the fixed retractor blade


50
45
40
35
30
25
20
15
10
5
0
mm Hg
0
5
10
15
20
25
30
Minutes
Constant Exposure
Constant Pressure

Goal	Intervention	Comments	
		Advantage	Disadvantage
Anesthesia	Isoflurane	Well studied	Hypotensive
	Propofol	Intravenous administration, reliable evoked potential recordings	Hypotensive, expensive
Metabolic depression	Barbiturates	Well studied	Delayed recovery
	Etomidate	Rapid recovery	? effective as barbiturates
	Hypothermia (mild)[b]	Probably quite effective	Mildly cumbersome, some delay in extubation
	Hypothermia (deep)	Circulatory arrest	Very cumbersome, coagulopathy
Improve cerebral blood flow	Mannitol	Effective	? cerebroprotective value
	Induced hypertension	Effective	Increased bleeding
Minimize Ca^{++} injury	Nimodipine	Probably effective	Hypotension, no intravenous form at present in U.S.
	Hypothermia (mild)[b]	Probably quite effective	Mildly cumbersome, some delay in extubation
Electrophysiological monitoring	Electroencephalogram	Standardized monitoring	? sensitive to deep ischemia, limits anesthetic options
	Evoked potentials	Sensitive to cortical and subcortical ischemia	Only certain regions of brain readily monitored

Goal	Intervention	Comments	
		Advantage	Disadvantage
Cerebral blood flow monitoring	Laser-Doppler	Relatively easy to implement	Local cerebral blood flow only, errors likely
	Thermal diffusion	Relatively easy to implement	Local cerebral blood flow only, errors likely
	Transcranial Doppler	Relatively easy to implement	Large vessels only, difficult to monitor ipsilaterally
Increase exposure	Positioning	Practical	Limited application
	Cerebrospinal fluid drainage	Relatively simple	Injury caused by intracranial shifts
	Cranial base removal; osteotomy	Effective	Technically demanding, time consuming
	Hyperventilation	Effective	Decreased cerebral blood flow, alkalosis
	Brain retraction	No injury if appropriate	Safe limits variable
	Brain resection	Effective	Destructive
Minimize retraction injury	Retraction pressure monitoring: <40 mm Hg	Effective	Mildly cumbersome
	Intermittent retraction: <15 min on, 5 min off	Probably effective	Delays surgery, ? increased reperfusion injury
	Multiple retractors	Possibly effective	More cumbersome than fewer retractors

ULTRASONIC SURGICAL ASPIRATORS

- The original ultrasonic aspirator was developed in 1947 for the removal of dental plaques.
- field of eye surgery in 1967 ,based on the principle of phaco-emulsification.
- First devoloped in 1976 in the US
- Suction device with a tip that vibrates at ultrasonic speed
- Sonic energy disrupts and fragments
- Diluted and aspirated

- A console and handpiece
- Console has the ultrasonic generator- 2 types

electrostriction,	magnetostriction
piezoelectric ceramic crystals	change in dimensions of a magnetostrictive transducer
crystals decay	not subject to decay

- Titanium tip vibrates longitudinally at a speed of 23 to 35 khz ,
- amplitude of 100 – 300 microns ,function of setting the vibration level
- small amplitude – disruptive effect restricted to

- Hand piece,

  stright   vs Angled

  short   Vs   Long

  internal vs external coaxial irrigation system

  different frequencies

- Irrigation system

  to suspend the fragmentaed tissue, to cool the transducer and to prevent the blockage of suction system

Mechanism

- Simultaneouly fragment,emulsify and aspirate parenchymal tissue rapidly
- Vacuum effect
- Cavitation
- Rupture
- Susceptibility depends upon-

    water content

    sensitivity to vibration

Fat and brain easily disrupts Vs vessel and nerves

- Tissues with weak intracellular bonds, such as tumors and lipomas, are easy to fragment, whereas tissues with strong intracellular bonds,such as nerves and vessel walls, are difficult to fragment

- Low frequency → high amplitude

  Useful in hard and partially calcified tumors

- High frequency → low amplitude

  useful while working near vital structure

adjustments of the vibration energy,irrigation rates and the suction pressures along with the use of appropriate hand piece optimizes the use

Advantages

- Minimizes,
  - mechanical manipulation
  - Traction on adjascent tissue
- Avoids thermal injury of cautery
- Clear and less crowded operative field
- Vs laser UA are faster ,good visualization of tumor brain interphase. Laser is more precise
- Suitable for HPE as they are not significantly distorted

Complications

- Penetrating injury
- ? Transmission of ultrasonic energy to adjascent vital structures throgh bone
- Reports of multiple cranial nerve palsies

“Winning is overrated. The only time it is really important is in surgery and war.”

Thank you