Cavitron Ultrasonic Surgical Aspirator (CUSA)

Presented By:
Ramandeep Singh

History

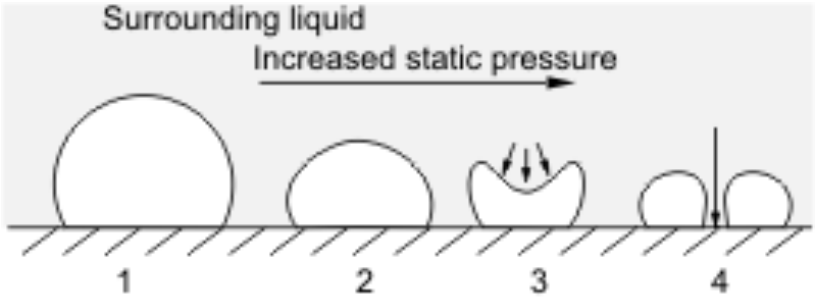
In 1916, the physicist Lord Rayleigh discovered the effect of cavitation while investigating damage to a ship's propeller. He concluded that the collapse of the bubbles created a small jet stream of water, which was responsible for the structural damage. Using a similar principle, high speed mechanical waves can be used in non-elastic media, such as water, to create a cavitation effect. If this phenomenon is applied to water-rich tissues, such as liver, the final effect is the destruction of all the cells, preserving structures rich in collagen (low in water), such as blood vessels, nerves.

Cavitation

•Cavitation is defined as the process of formation of the vapour phase of a liquid when it is subjected to reduced pressures at constant ambient temperature.

•Thus it is the process of boiling in a liquid as a result of pressure reduction rather than heat addition.

•Cavitation occurs when, on the negative side of a pressure cycle, such as when the probe-tip is retracting with sufficient amplitude and frequency, suspended gas bubbles either within fluid, tissue or trapped at solid interfaces expand and collapse resulting in the generation of shock waves.



Cavitation bubble imploding close to a fixed surface generating a jet (4) of the surrounding liquid.

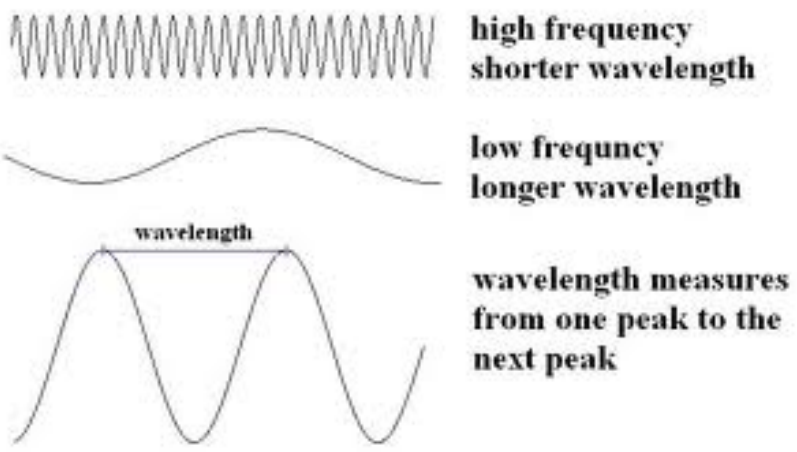
Ultrasound

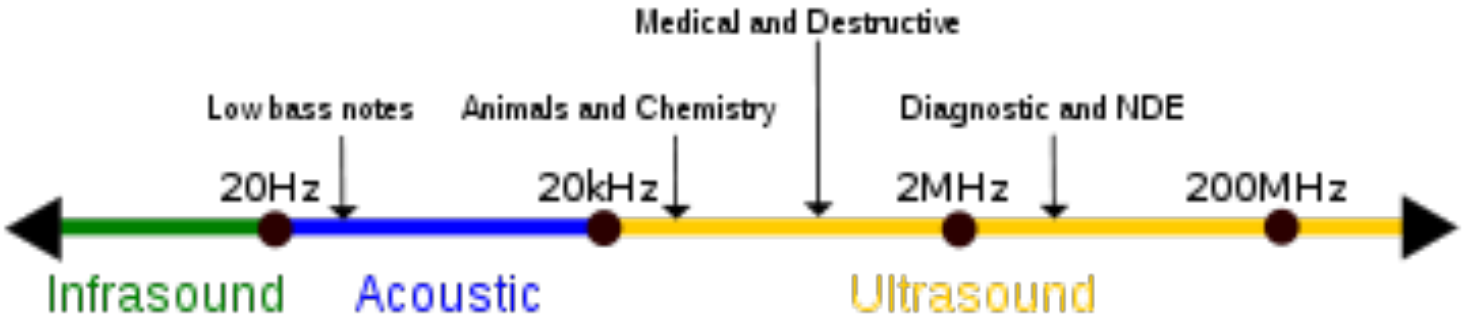
Audible Range: 20 Hz ----- 20,000 Hz.

Infrasonic waves: Sound waves with frequencies < 20 Hz.

Ultrasonic waves:

Sound waves with frequencies > 20,000 Hz.





Aspiration

Aspiration means to draw in or out using a sucking motion. This term has two meanings depending on how it is used.

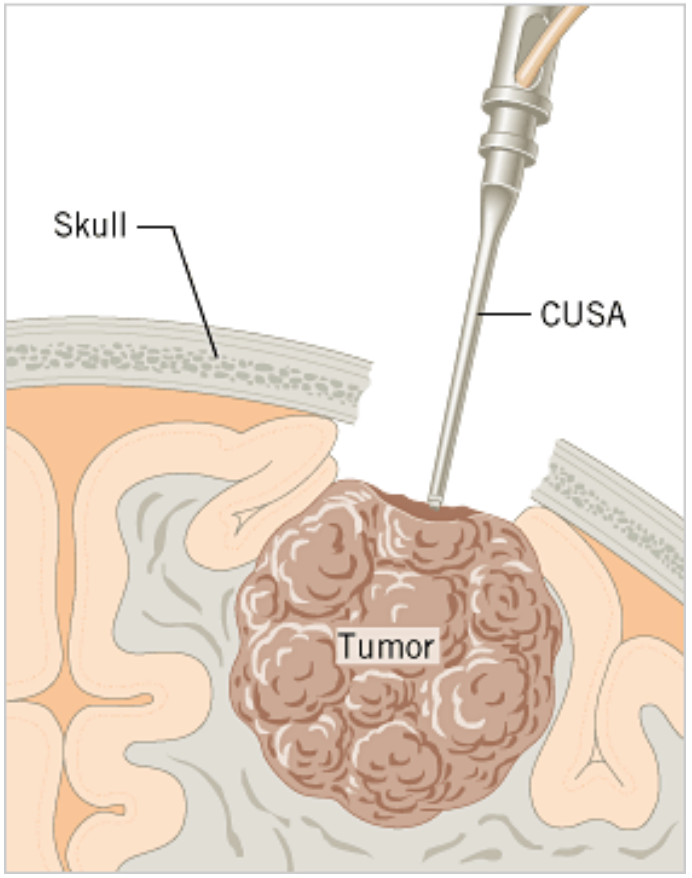
- Aspiration can mean breathing in a foreign object.
- Aspiration can also refer to a medical procedure that removes harmful or misplaced substances from an area of the body.

Suction is basically aspiration of a gas or fluid by reducing air pressure over its surface, usually by mechanical means or negative pressure device.

The cavitron ultrasonic surgical aspirator (CUSA)

Neurosurgeons use a cavitron ultrasonic surgical aspirator (CUSA) to “cut out” brain tumors without adversely affecting the surrounding healthy tissue.

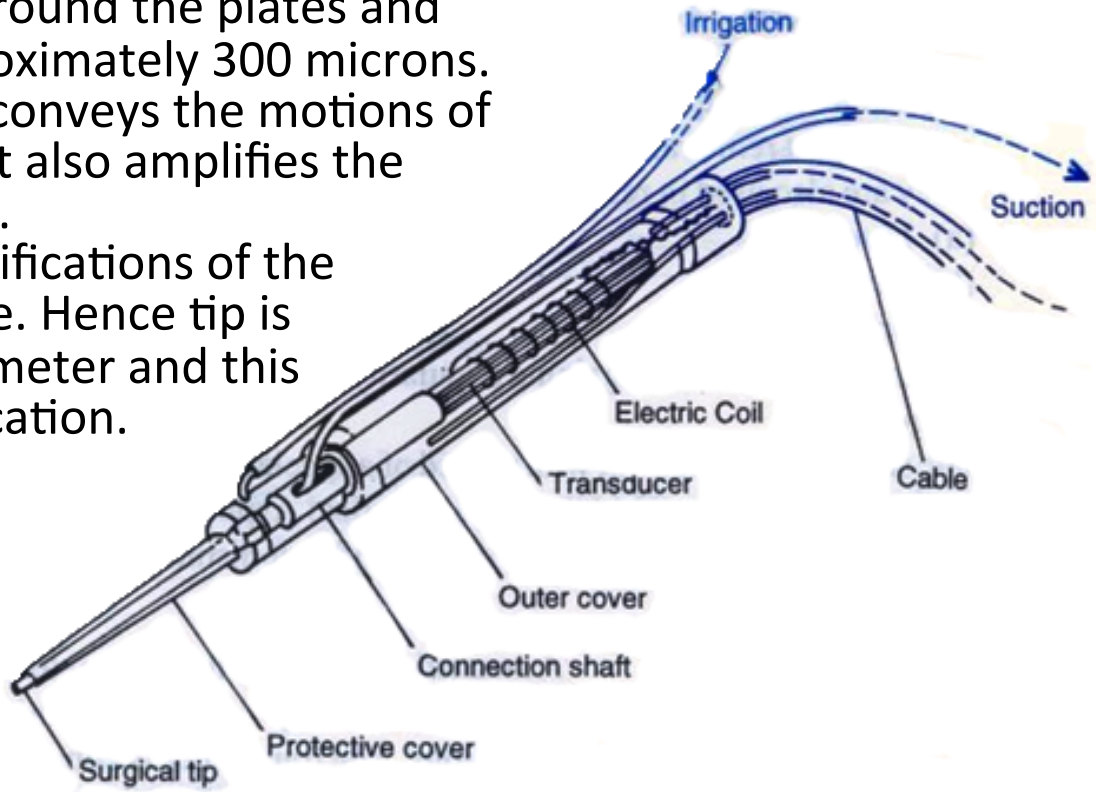
The cavitron ultrasonic surgical aspirator (CUSA) device generates ultrasonic waves in the range of 23 kHz to produce tissue cavitations. This mechanical energy is delivered through a hollow 3 mm tip that vibrates at 23,000 cycles per second. The entire device is embedded with an irrigator and aspirator in order to dispose of the tissue debris.



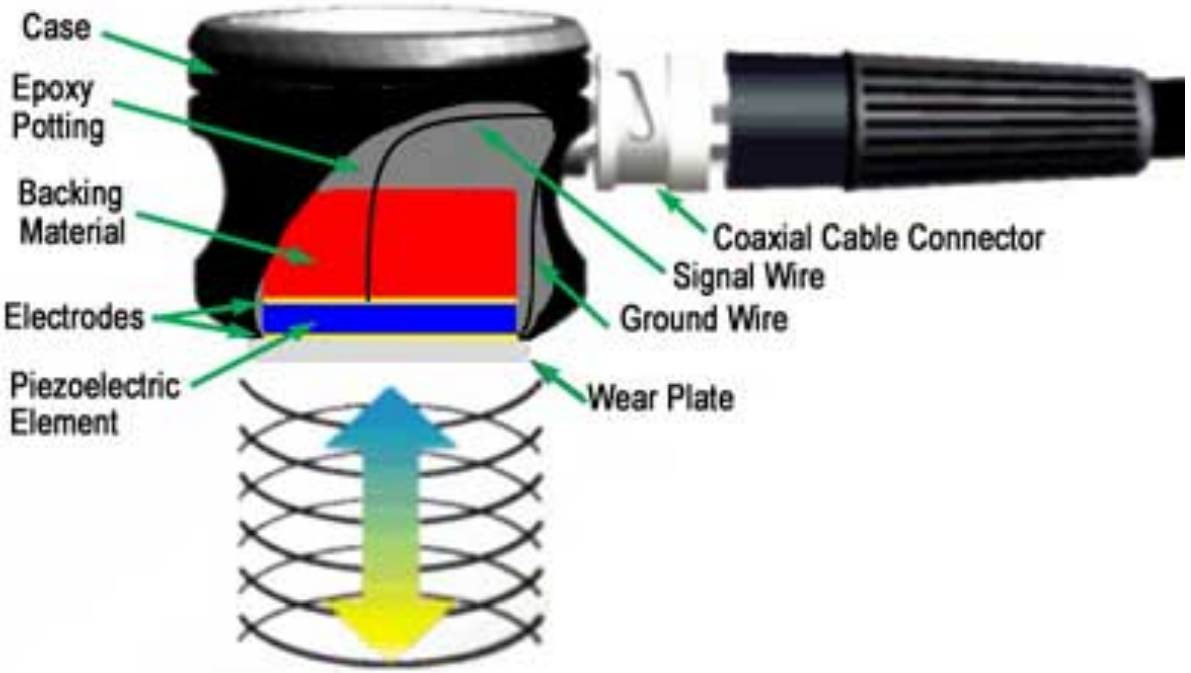
Components of CUSA probe

The CUSA probe consists of three distinct components:

- Transducer: A device that converts electromagnetic energy into mechanical vibrations. The transducer is composed of a stack of nickel alloy plates. A magnetic field is produced by a coil placed around the plates and causes mechanical motion of approximately 300 microns.
- Connecting body: Mechanically conveys the motions of the transducer to the surgical tip. It also amplifies the vibration motion of the transducer.
- Surgical tip: Completes the amplifications of the motion and also contacts the tissue. Hence tip is relatively long compared to its diameter and this provides adequate motion amplification.



Piezoelectric Transducer



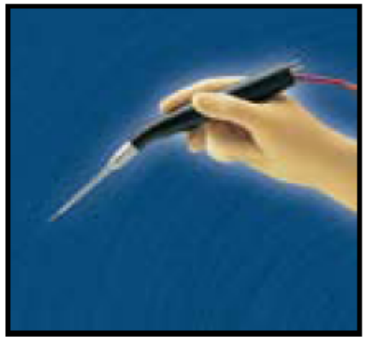
Piezoelectric transducer is used to produce and detect Ultrasonic Waves.

It is a quarts crystal which converts electrical oscillations into mechanical vibrations (sound) and vice versa.

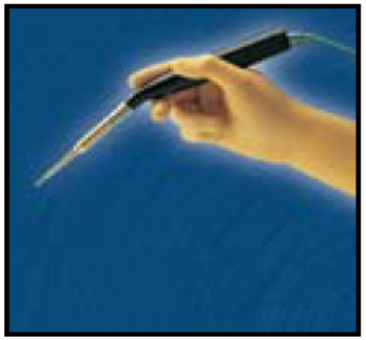
Mechanics of CUSA

- The CUSA console provides alternating current (24 or 35 kHz) to the handpiece. In the handpiece, the current passes through a coil, which induces a magnetic field.
- The magnetic field in turn excites a transducer of nickel alloy laminations, resulting in oscillating motion in the transducer laminated structure—vibration—along its long axis.
- The transducer transmits vibrations through a metal connecting body to an attached surgical tip.
- When the vibrating tip contacts tissue, it breaks cells apart (fragmentation). The CUSA system supports different magnetostrictive handpieces based on frequencies, and each supports multiple tip designs.

Effect of different frequencies



The 24 kHz handpieces are designed for applications requiring higher power and faster tissue removal.



The 35 kHz handpieces are designed for applications requiring lower power and greater precision.

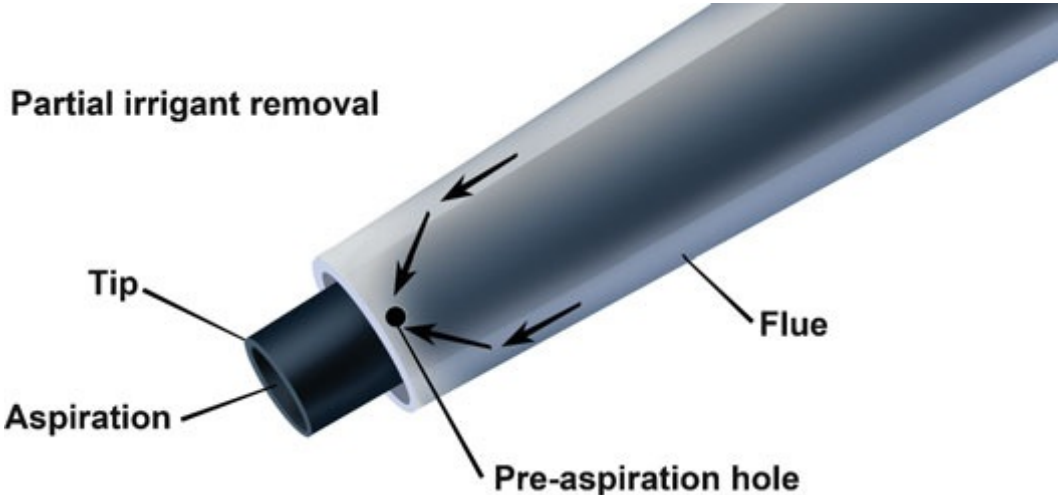
24 kHz Tissue Effect

35 kHz Tissue Effect

The powerful 24 kHz handpiece fragments even tough, fibrous, and calcified tumors while the small, 35 kHz handpiece is helpful during procedures requiring precision, tactile feedback, and delicate control. A wide variety of tips enables customization of the handpiece for each procedure, depending on the consistency, location, and depth of the targeted tissue.

SUCTION AND IRRIGATION

The CUSA has a self-contained suction capability to remove fragmented tissue and irrigation fluid.



The Suction and Irrigation performs three function in CUSA operation:

1. It draws tissue toward the vibrating tip, and creates a tip/tissue coupling effect.
2. It keeps the surgical site clear of irrigation and fragmentation debris .
3. Irrigation fluid flows coaxillary around the outside of the vibrating tip to keep the tip cool.

Conclusion

The surgical aspiration involves the effects and interplay of the following five variables:

- Operating frequency of the handpiece
- Tip cross-sectional area at the tissue contact site
- Stroke amplitude of the tip
- Tissue type
- Suction level

As a whole, the utilization of ultrasonic aspiration

- Increases safety,
- Reduces operating time,
- Improves quality and
- Facilitates selective surgery.

There are no known contraindications. There are only limitations (financial, personal, etc.),