Söring

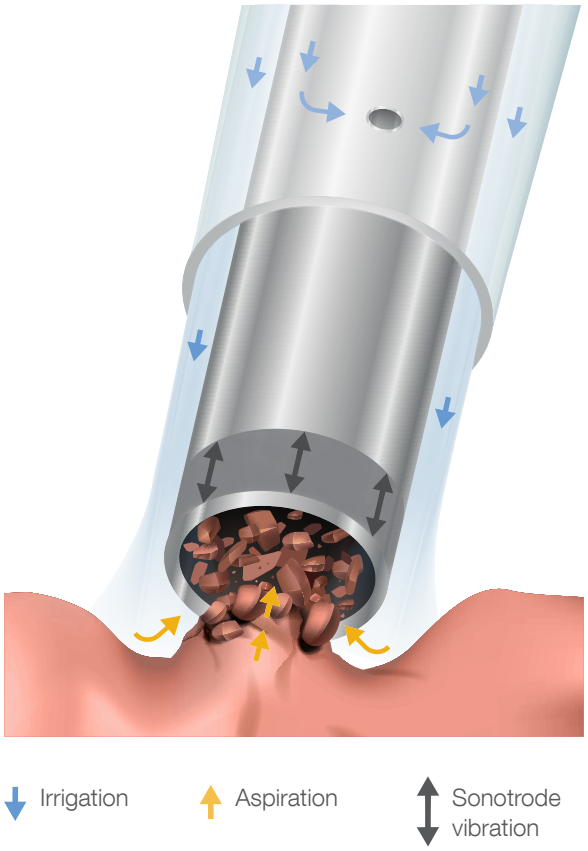
IN PRACTICE:
Ultrasonic fragmentation in neurosurgery

With a LEVICS ultrasonic instrument tumor tissue is fragmented precisely and selectively. The instrument includes a sonotrode with an oscillation frequency of 35 kHz and an irrigation-aspiration system. The extent of fragmentation is determined by the strength of the oscillation, the level of aspiration pressure, the contact force between the sonotrode and the tissue, and the mechanical tissue properties of the tumor tissue.

Role of 35 kHz sonotrode oscillation frequency

The sonotrode vibrates back and forth with an amplitude of approx. 30-200 µm. When it enters into contact with enough tissue, the sonotrode tip hits the tissue at up to 7 m/s during this oscillation and mechanically breaks the cell bond (also known as the “jackhammer effect”). The mechanical tissue effect increases as the contact force increases.

In addition, the sonotrode vibration emits a sound field, causing alternating high- and low-pressure phases in the environment. Cavitation bubbles may form during the low-pressure phases. Imploding cavitation bubbles generate powerful pressure pulses as well as shock waves, which can lead to tissue removal (see background information on page 2).
The mechanical and cavitational effects associated with sonotrode vibration intensify as the vibration amplitude increases. The energy input of the vibration is quadratically dependent on the amplitude: vibration energy is quadrupled when amplitude is doubled.

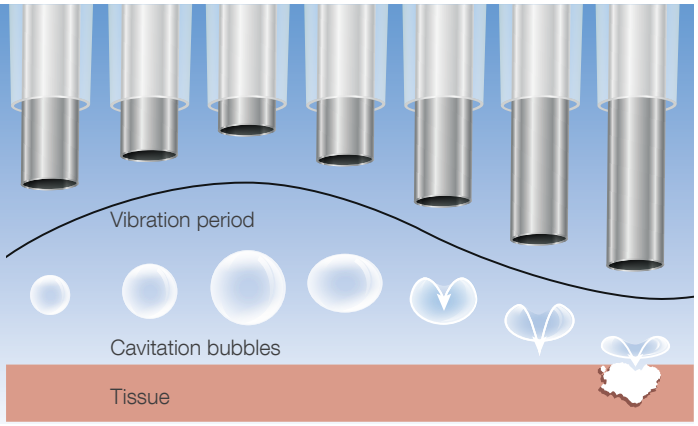


Impact of aspiration on the tissue effect

In addition to the vibration energy, the acting contact force also determines the extent of the mechanical tissue effect, and thus the mechanical tissue fragmentation. The tissue is effectively pulled towards the sonotrode tip using aspiration, which applies contact force to the tissue. The oscillation takes effect and fragments the tissue. Higher aspiration pressures exert stronger contact forces on the tissue and lead to a higher fragmentation rate – while the tissue properties remain the same. Therefore, aspiration significantly facilitates mechanical tissue fragmentation via the contact force.

Background information on cavitation

The sound field emitted is characterised by powerful high- and low-pressure phases. Cavitation bubbles oscillate non-linearly with the sound field, sometimes over many vibration periods, until they implode during compression. Near interfaces, the bubbles implode aspherically, forming a water jet with considerable velocity.



Tissue interaction

The degree of tissue softness or firmness, i.e. the tissue's mechanical properties, has a decisive effect on the respective extent of fragmentation. Basically, higher amplitude (referred to as "Ultrasound" in the control panel) and aspiration pressure settings are required to ensure the efficient fragmentation of firm tissue. Higher amplitude and aspiration pressure settings also require a higher irrigation rate. This provides the cavitation effect and minimises thermal tissue stress. However, efficient tissue fragmentation can be achieved with even lower settings that are aligned with each other. Handling it in the same way with unnecessarily high settings does not result in a higher fragmentation rate. Therefore, the tissue's mechanical properties must be taken into account to use the LEVICS instrument efficiently. To achieve the desired tissue effect, the amplitude, aspiration and irrigation settings must always be adjusted according to the tissue present and the desired fragmentation rate.

Ideally, the choice of settings for the three parameters (amplitude, aspiration and irrigation) can be based on the ALARA principle: "as low as reasonably achievable". This means that the settings should be chosen to be as high as necessary and as low as possible.

Therefore, the optimal settings are selected based on the mechanical properties of the tissue and the desired fragmentation rate.

Key points on ultrasonic fragmentation

- *In addition to the amplitude, the level of aspiration pressure plays a significant role in determining the tissue effect*
- *Settings should be selected based on the existing tissue properties and the desired fragmentation rate*
- *Settings for amplitude, aspiration and irrigation must be aligned to achieve the desired dissection effect*
- *Unnecessarily high settings do not necessarily result in a higher fragmentation rate*

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