İNCELER MEDİKAL R&D
TEST-MEASUREMENT LABORATORY

ESWT TECHNOLOGY PRINCIPLES AND COMPARISON

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FOCUSED ESWT SHOCK WAVE CHARACTERISTICS

Extracorporeal Shock Wave Therapy (ESWT) is a non-invasive method and is widely used in urology as well as in various musculoskeletal diseases. Extracorporeal Shock Wave Therapy (ESWT) is a non-invasive method and is widely used in urology as well as in various musculoskeletal diseases. There are 3 mechanisms for generating shock waves: electrohydraulic, electromagnetic, and piezoelectric.

- In **electrohydraulic** devices, shock waves are formed as a result of the discharge of the electrode in a liquid medium due to the high voltage applied to its ends. This shock wave is focused with the help of a reflector. [1]
- The working principle of **electromagnetic** shock wave devices is based on the induction of a magnetic field, and the shock wave is focused using acoustic lenses.
- In **piezoelectric** ESWT devices, a large number of piezo crystals are placed inside a sphere and a rapid electrical discharge is provided. As the crystals contract and expand, a pressure is created in the water and a shock wave is produced. Focusing is determined by the geometric arrangement of the crystals inside the sphere.

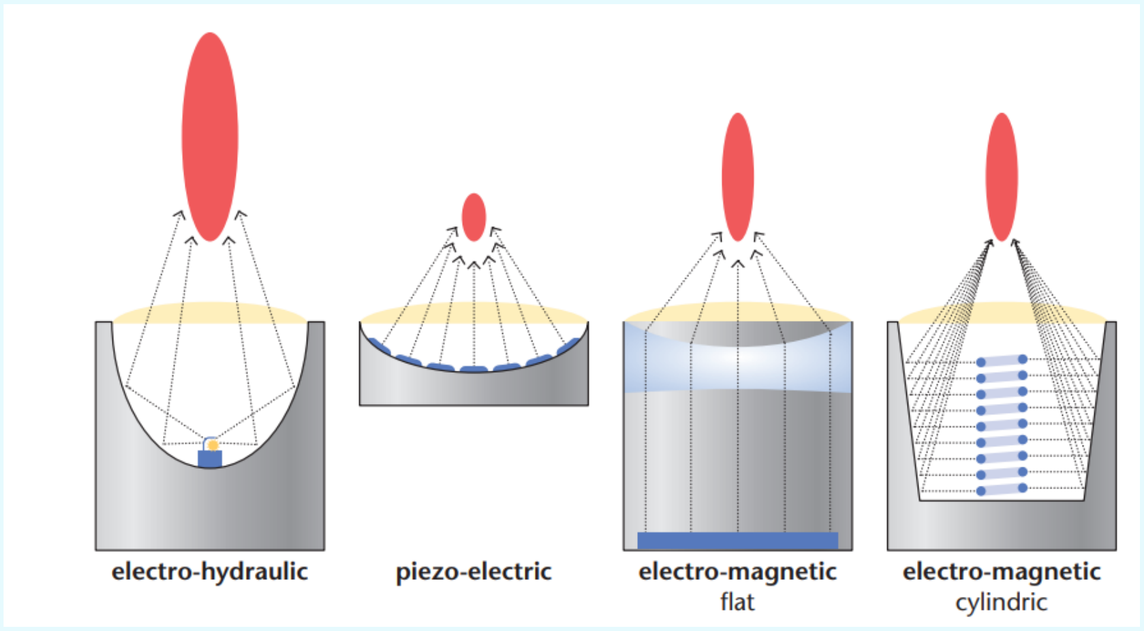

Figure 1. Different types of generating pressure waves and shock waves are produced by the diverse devices for ESWT [2]

ESWT Device Comparison

- **Waveform Specifications**

Electrohydraulic devices produce shock waves with shorter rise times than piezoelectric and electromagnetic devices. The rise times of electrohydraulic devices have been measured as approximately 35 ns, while the rise time for the Modus Focused ESWT device is 31 ns. This allows the energy to be transferred to the targeted area more quickly and the signal is less distorted while reaching the target. Since the rise time in piezoelectric and electromagnetic devices is longer, oscillations and distortions are observed more in the waves produced by these devices. For these reasons, the short rise time in electrohydraulic devices provides effective treatment to the desired area in shock wave therapy application. [3]

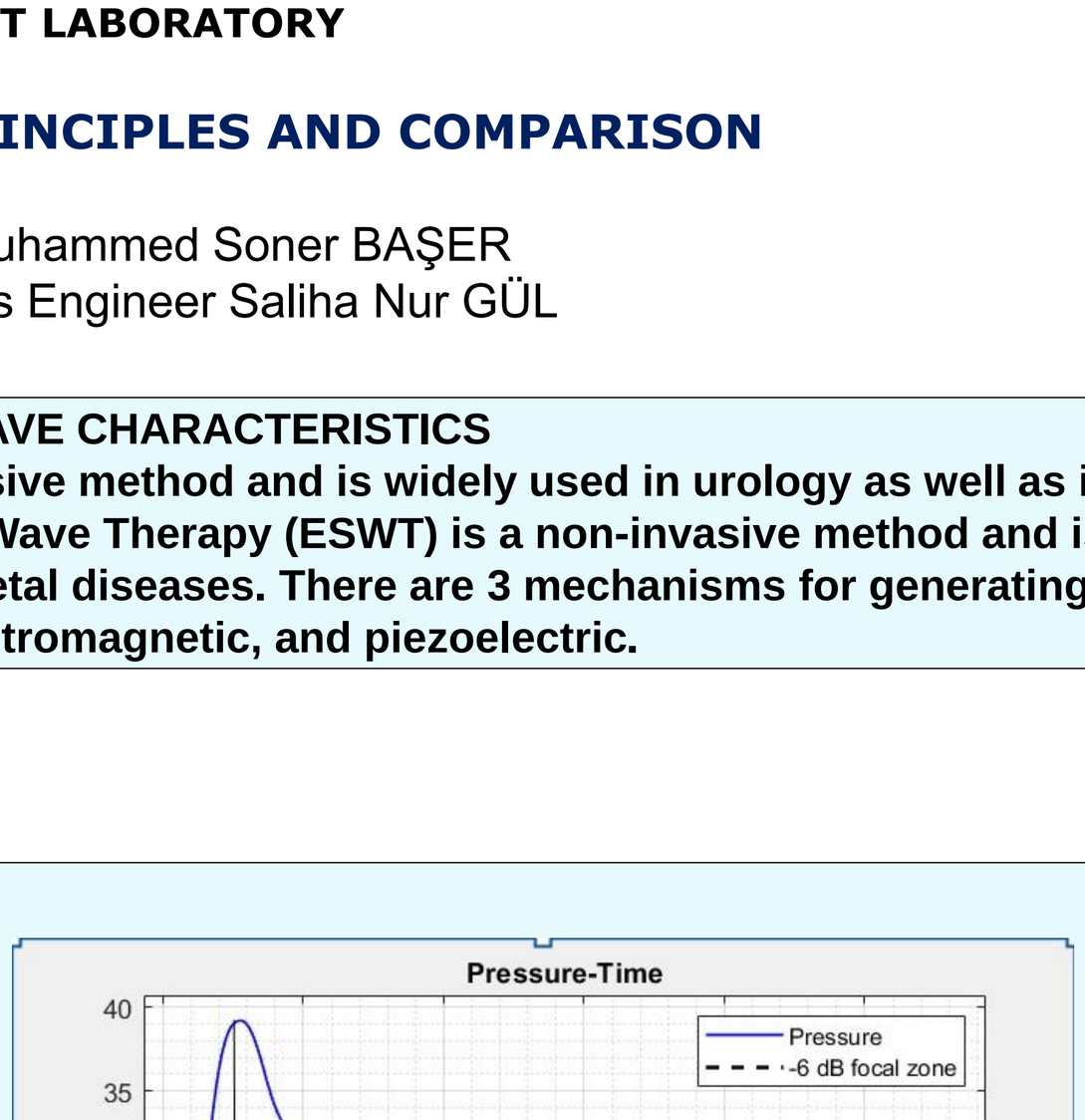

Figure 2. Pressure- Time Wave of Modus Focused ESWT based on hydrophone measurements

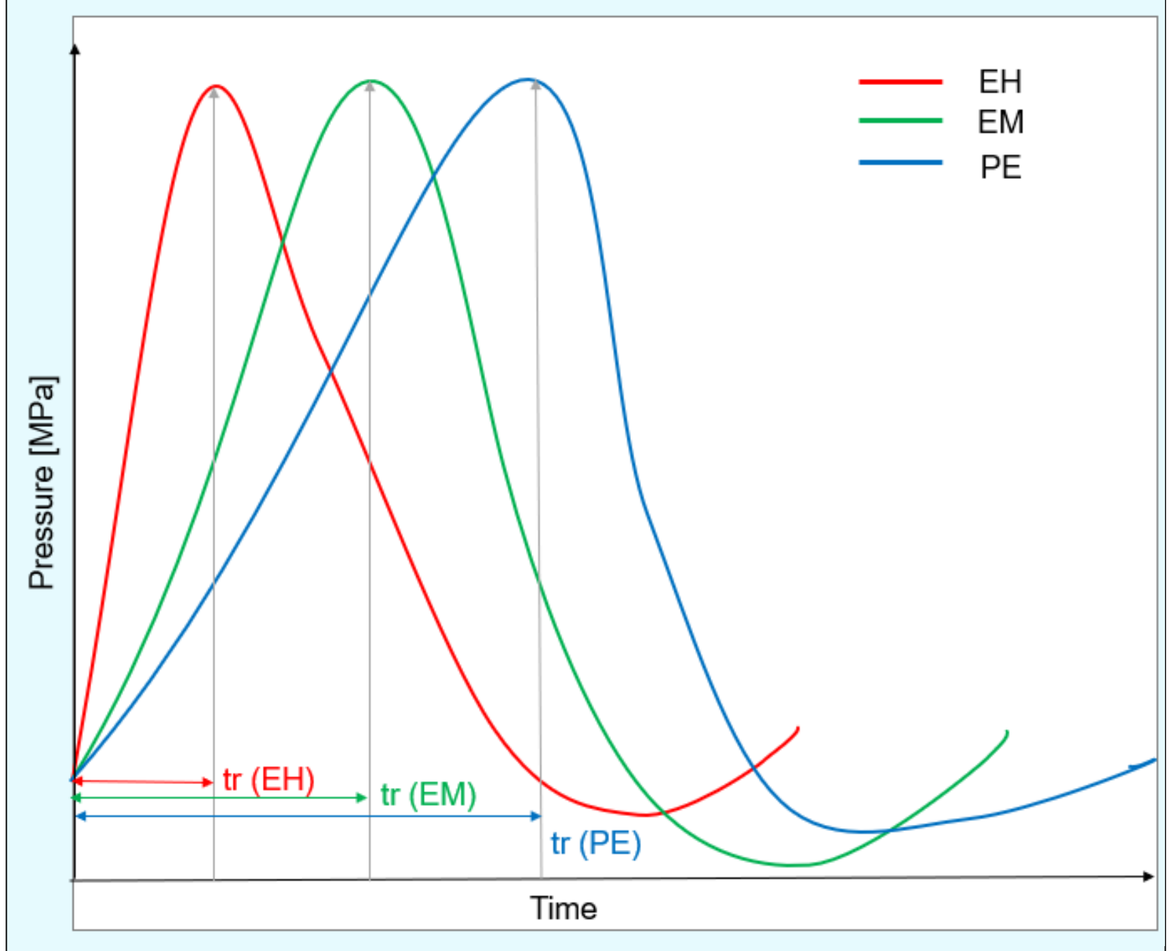

Figure 3. Rise Time Comparison of three ESWT Mechanisms, EH (Electrohydraulic), EM(Electromagnetic), PE(Piezoelectric)

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- **Penetration Depth**

The penetration depth of the piezoelectric shock wave is usually up to 5 cm and is the device that reaches the lowest treatment depth.
The penetration depth of electromagnetic shock waves is around 6 cm, providing a more effective treatment depth than piezoelectric devices [4]. While the penetration depth is higher in electrohydraulic shock wave devices, the maximum penetration depth in the Modus Focused ESWT device is up to 8.45 cm. This situation creates an advantage for both near-surface and deep treatments.

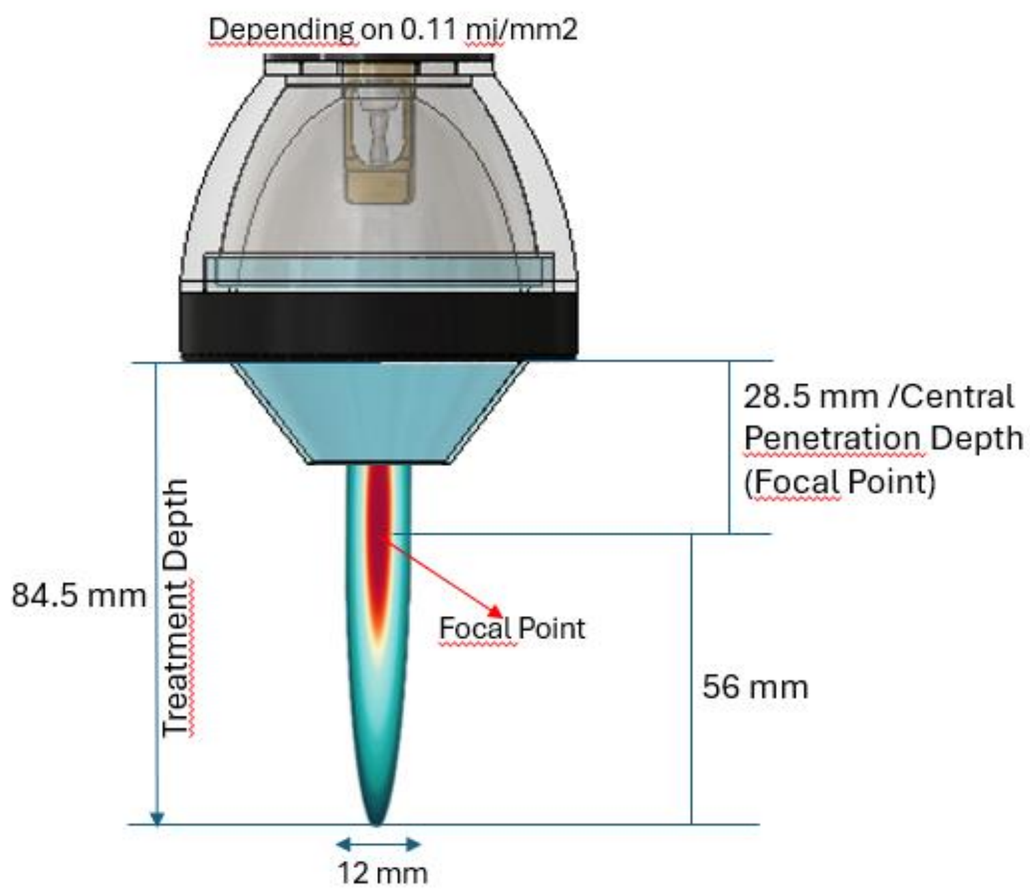

Figure 4. Penetration Depth Representation of Modus Focused ESWT

- **Treatment Zone**

Piezoelectric devices have the smallest focal volume, which can make it difficult to precisely target the correct area. Although electromagnetic type devices affect a larger treatment zone than piezoelectric type devices, they do not have as large a treatment volume as electrohydraulic devices. The devices that reach the highest area in the -6 dB focal region are electrohydraulic devices. The high energy and strong focusing feature of electrohydraulic technology makes it possible to apply treatment to larger areas [5]. Since it has a large focal volume, it has been observed that it shortens the treatment time by providing more energy transfer to the treated area for a given energy flow density (mj/mm2).

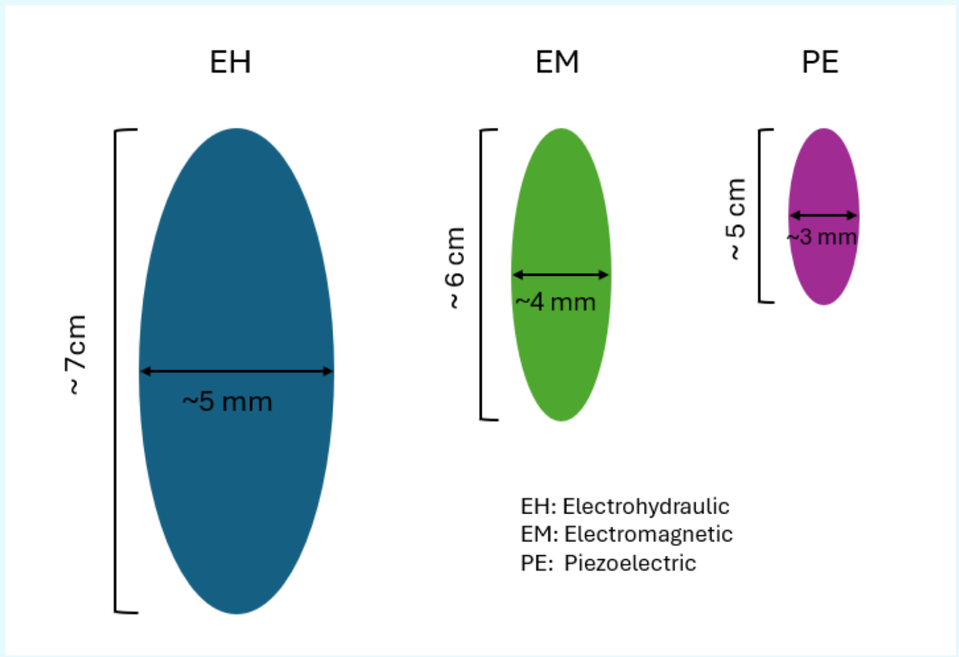

Figure 5: Focal Zones and Treatment Depth of EH, EM and PE ESWT Devices

- **Energy Level and Treatment Effectiveness**

Electromagnetic and piezoelectric devices produce lower energy levels than electrohydraulic devices. Due to the higher energy level, treatment times and sessions are shorter in electrohydraulic devices than in other types of devices [6]. See in Table-1.

- **Overall Effectivenes**

Electrohydraulic ESWT devices offer advantages over electromagnetic ones due to their simple design, low cost, and superior energy capacity [7]. While electromagnetic devices can lose up to 50% of their peak pressure over time, electrohydraulic devices ensure better reproducibility through their electrode structure and high plasma expansion from electric discharge. Despite being noisier, electrohydraulic devices are especially effective for hard tissue treatments, enhancing treatment success with their high energy output and broad treatment areas.

TABLE-1. ELECTROHYDRAULIC AND ELECTROMAGNETIC DEVICE PARAMETERS COMPARISON	Storz Duolith SD1	İnceler Medikal Modus Focused ED
Price	Costly	Low-cost
Type	Electromagnetic	Electrohydraulic
Focal Diameter(mm)	2.8 mm	4 mm
-6dB Focal Area(mm2)	6.15	12
Total Energy per Shot in -6dB (mj)	0.67(at 0.11)	1.32
Treatment Depth (mm)	50 (at 0.55)	84.5 (at 0.11)
Recomended shots per session for ED	3000	2400
Total energy/treatment in -6dB	12.06 J	19.00 J

[1] [3] [6] Gladys L.Y. Cheing, Hua Chang. :Extracorporeal Shock Wave Therapy, Journal of Orthopaedic and Sports Physical Therapy, 2003
[2] Vinzenz Auersperg, Klemens Trieb.: Extracorporeal shock wave therapy: an update, EFORT Open Reviews, 2020
[4] Saxena, A. and Shou, L., 2019. Combined ESWT & RSW Therapy for Achilles Tendinopathy: A Prospective Study. Muscles, Ligaments & Tendons Journal (MLTJ), 9(4).
[5] [7] Achim M.Loske.: Medical and Biomedical Applications of Shock Waves, Springer, 2017