

# Extracorporeal Shockwave Therapy in Dentistry: Harnessing Shock Waves for Dental Therapeutics

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## Abstract

Extracorporeal Shock Wave Therapy (ESWT) has emerged as a promising treatment modality in dentistry, offering non-invasive and effective solutions for various dental conditions. This review article aims to provide an overview of the current state of research on ESWT in dentistry, focusing on its applications, mechanisms of action and clinical outcomes.

ESWT utilizes high-energy acoustic waves to stimulate biological tissues, promoting tissue regeneration, angiogenesis and pain relief. In dentistry, ESWT has been explored for the management of conditions such as periodontitis, peri-implantitis, Temporomandibular Joint Disorders (TMDs) and orofacial pain syndromes. Studies have demonstrated the efficacy of ESWT in reducing inflammation, promoting wound healing and improving clinical outcomes in these conditions.

Furthermore, ESWT has shown promise in enhancing the outcomes of dental implant therapy by improving osseointegration and reducing implant failure rates. The non-invasive nature of ESWT, along with its minimal side effects and high patient acceptance, makes it a valuable adjunctive therapy in dental practice.

ESWT thus represents a novel and effective approach in the management of various dental conditions. Further research is warranted to explore its full potential and establish standardized protocols for its use in dentistry.

**Keywords:** Extracorporeal Shockwave Therapy; Dentistry

## Introduction

Researchers in the medical sciences have always aimed to create novel therapeutic approaches. One such is the Extracorporeal Shock Wave Therapy (ESWT) which has gained popularity in the recent days. Extracorporeal Shock Wave is a low-frequency, high-energy, pulsating sonic wave of short duration, generated outside the body [1].

These shock waves were discovered by an accidental finding at the Dornier in 1966. An employee experienced a sensation in his body like an electric shock during high-speed projectile trials when he touched the plate at the same moment a projectile hit it. There was no detected electricity, yet the waveform was thought to be moving from the plate across the hand and into the body. These waves have been in use in the medical field since decades after its discovery, first being used in Urology in 1960s. From then on it has been used to treat bone and other musculoskeletal conditions such as tendinitis, nonunion fractures, aseptic necrosis of the bone and myofascial disorders [2]. This was fundamentally for its non-invasive, safe, low-cost and fast application. A series of studies showed a positive effect of ESWT in different tissues such as cardiovascular, neural and skin [3-5]. The International Society for Medical Shockwave Treatment (ISMST) suggests a few salient characteristics of shock waves. It characterises shock wave as a sonic pulse exhibiting a broad frequency spectrum, an abrupt increase in pressure, a short life cycle and a high peak pressure [6].

ESWT gained growing interest from researchers and clinicians in expanding the areas of potential use. It has established anti-bacterial, anti-inflammatory and potential regenerative properties. This has increased its application in the field of dentistry as well [7].

It is important to know the basic working of these shock waves which forms the basis of their application in medical /dental field. The aim of this review is to comprehensively synthesize and highlight the diverse potential applications of Extracorporeal Shock Wave Therapy (ESWT) in dentistry, thereby creating a clear and accessible resource for students and clinicians. By consolidating current evidence and emerging insights, this article seeks to encourage deeper understanding, inspire further research and support the thoughtful integration of ESWT.

### **Shock Waves**

Shock waves are mechanical waves. They travel through a medium which changes its density from time to time [8]. It is important to consider two medias which is of concern: Water and Human tissue. ESWT travels through human tissue to reach the target site. Also based on the therapeutic indication and devices used, there are two types of shock waves: Focused and Radial [6,7]. They can be put into use depending on the indicated target depth and surface area. Focused waves have a deeper penetration depth and covers a minimal surface area whereas radial shock wave is considered a second-generation shock wave because of its lower energy and more linear pressure with less penetration depth. It has been demonstrated that focusing devices can attain penetration depths of over 10 cm, while radial devices can only reach levels of about 1.5 cm [8].

Devices that generate shock waves have different mechanisms of producing a waveform via electrohydraulic, piezoelectric and electromagnetic and pneumatic stimulation. All methods can generate focused shock waves, while some electrohydraulic and electromagnetic devices can emit radial shock waves [8,9]. Regardless of the waveform and pattern of propagation, the safety and effectiveness of ESWT are mainly determined by a dosage regimen of basic parameters such as the total number of shocks and the energy flux density, which is expressed in  $\text{mJ}/\text{mm}^2$  and the shocks per second (Hz) rate [9]. Important additional factors for effective ESWT include treatment frequency (i.e., rounds of exposure) and dose interval. It is possible to conceptually replicate the safety-efficacy and dose-effect parameters with a pharmaceutical dose that is uniquely designed for a given treatment [10].

### **Biological Effects of Shock Waves**

It's still unclear what characteristics of pressure waves cause the body tissues to react. It is possible to see temperature variations, pressure gradients and cavitation in the target tissues [10,11]. Shock waves tend to increase the permeability of cells for various cellular proteins like transforming growth factor-beta1, bone morphogenetic proteins and other membrane-bound proteins [12]. They also cause microscopic metabolism and increased vascular circulation at the target region [13,14]. A mechano-transduction process is said to be involved in the conversion of physical energy into a biological response in the tissues exposed to ESWT. First the cell skeletal structures are activated, which leads to the release of mRNA from the cell nuclei. This is followed by activation of cell organs such as the mitochondria and the endoplasmic reticulum and the cell vesicles, which release the specific proteins of the healing process which explains its biological activity on target tissues. Studies on animal models have suggested that shock waves produce free oxygen radicals that induces production of growth factors [8,15]. ESWT initiates, induces and intensifies the processes involved in cell regeneration which involves the activation, migration and interplay of several cell types. This eventually causes expression of cell surface receptors. Cytokines then stimulate these receptors, triggering the interactions thus intensifying its regeneration impact [16]. These properties form a basis for the dental application of shock waves.

### **Dental Applications**

The application of ESWT in dentistry has grown due to its well-researched antibacterial, anti-inflammatory, stimulating and restorative qualities which is discussed in detail further on [17]. In the oral and maxillofacial areas, ESWT is indicated due to its promising potential. The complex and diverse anatomical and histological structures of the oral and maxillofacial area include glandular, bone/musculoskeletal, soft tissue and tooth-related conditions [16]. ESWT has several uses, such as treating sialolithiasis, TMJ Disorders, bone/fracture healing, implant therapy, orthodontic tooth movement and periodontal therapy [17].

#### *Salivary Gland*

The benign disease known as sialolithiasis is characterized by the development of stones in the ductal system of the three main salivary glands: the parotid, submandibular and sublingual glands [18]. Several diagnostic tools and conservative treatment

modalities have been used, such as prescribing a sialagogue, salivary gland massage and Non-Steroidal Anti-Inflammatory Drugs (NSAIDs). Nevertheless, every so often conservative treatment approaches fail to control the condition and planning alternative treatment is required such as sial endoscopic extraction through the salivary duct, basket retrieval systems or laser fragmentation [19].

An extracorporeal method of breaking sialoliths using ESWT is not particularly effective, but it has relatively few adverse effects, therefore it can be regarded as a first line of treatment to save the gland rather than removing the salivary gland entirely. According to Aidan, et al., the rate at which the sialolith completely disappears after receiving ESW treatment varies from 18% to 58% [20]. As the shock waves travel through the tissues, they cause rapid changes in pressure. This creates a phenomenon known as cavitation. Cavitation refers to the formation, growth and implosion of tiny bubbles within the tissues. The rapid expansion and collapse of these bubbles create shear stress on the sialolith [18,19]. This stress causes the stone to fragment into smaller pieces. The repeated application of shock waves causes further fragmentation of the sialolith into even smaller particles. Once the sialolith has been sufficiently fragmented, the smaller particles can be expelled naturally through the salivary duct or may be removed manually or with the help of flushing [19]. Better outcomes were seen in parotid sialolith. But the main side effects were pain and discomfort during the session [21]. This minimally invasive technique was created to replace gland excision procedures and the associated dangers (mostly from facial nerve damage from parotidectomies of nerve or tissue damage) [20].

#### *Temporomandibular Joint Disorder*

Myofascial pain is a primary symptom of temporomandibular disorders. The analgesic effect of ESWT is produced by non-invasively stimulating cell membranes and nerve terminals, which inhibits the excitation and propagation of pain signals [22]. Moreover, it suppresses apoptosis, tissue disintegration, Interleukin-1 $\beta$  (IL-1 $\beta$ ), Tumor Necrosis Factor  $\alpha$  (TNF $\alpha$ ) and Interleukin-6 (IL-6), which are pro-inflammatory cytokines [23]. ESWT may stimulate the release of endorphins, which are natural pain-relieving chemicals in the body. This can help reduce pain associated with TMJ disorders and its anti-inflammatory effects, can help reduce inflammation in the TMJ and surrounding tissues. This is beneficial for TMJ disorders characterized by inflammation [22]. ESWT has been reported to promote the formation of new blood vessels (neovascularization) in the treated area. This can improve blood flow and oxygenation, which may aid in the healing of damaged tissues in the TMJ. ESWT also stimulates the production of collagen and other proteins [19]. This can help repair damaged tissues in the TMJ and improve joint function. The mechanical energy from the shock waves may help break down adhesions or scar tissue in the TMJ, improving joint mobility and function [22]. This lessens discomfort and helps with the problem of painfully limited mouth opening. A study found that ESWT outperformed other therapies in terms of pain threshold and severity, which in turn decreased the number of patients with myofascial pain syndrome in the neck and shoulder [24].

#### *Fracture/ Bone Healing*

The mandible is the most commonly injured and fractured bone in the maxillofacial area (52.9%). Fracture healing is a highly complex process affected by various biological and biomechanical factors. Post-operative risk of complications remains a significant drawback following oral and maxillofacial surgeries. Post-operative risk of complications remains a significant drawback following oral and maxillofacial surgeries. ESWT enhances bone mass density, promote blood flow and metabolic activity in the adjacent soft tissue and play a key role in pain relief [25]. These effects are influenced by regulating the expression of bone-specific extracellular matrix proteins with no adverse reactions [24,25].

#### *Osseointegration of Dental Implants*

After the surgical placement of a dental implant, an expected healing process ending with osseointegration is not always achievable due to the complexity of bone tissue dynamics and the balance between osteoblasts and osteoclasts. Apart from the failure of osseointegration, marginal bone resorption and peri-implantitis affecting 28% - 56% of the patients have been noted [26,27]. It was suggested that fibrinogen adsorbed over the implant and bone surface is the major protein responsible for the accumulation of macrophages on the surfaces of implant biomaterials [28]. The presence of antigens on the surface of dental implants triggers immune and inflammatory responses that in turn initiates foreign body reaction [29].

ESWT delivers high-energy shock waves to the bone around the implant site. This can induce microdamage in the bone, triggering a healing response [26]. The healing process may stimulate the recruitment and differentiation of osteoblasts, which are responsible for bone formation and remodeling, leading to enhanced osseointegration. Shock Waves also promote the

formation of new blood vessels (angiogenesis) in the treated area [28]. Improved blood supply will enhance the delivery of oxygen, nutrients and growth factors to the implant site, facilitating bone regeneration and osseointegration. It also causes increased bone density and improved bone-implant contact contributing to the long-term stability and success of dental implants [29]. ESWT also causes an increase in cell membrane permeability, thus triggering the release of cytoplasmic Ribonucleic Acid (RNA) through an active exosome-dependent process. This RNA can stimulate Toll-Like Receptor 3 (TLR3) in healthy neighboring cells. TLR3 is part of the innate immune system and modulates inflammation by stimulating the production of various cytokines [30]. By reducing inflammation, ESWT may promote better bone healing and implant integration. The mechanical energy from the shock waves can exert forces on the bone, stimulating cellular responses that promote bone growth and remodeling. This mechanical stimulation may enhance the biological response to the implant and improve osseointegration [28].

#### *Orthodontic Tooth Movement*

The innovative technique of extracorporeal shock wave therapy reduces tooth mobility and heals surrounding tissues. Through superoxide-mediated signal transmission and vascularization of the bone-tendon interface, the waves drive mesenchymal stem cell differentiation. They stimulate the development of osteoprogenitor cells into osteoblasts in the bone marrow by TGF- $\beta$  stimulation [15]. ESWT induce controlled microtrauma to the bone, stimulating bone remodeling processes that facilitate tooth movement [18].

#### *Periodontics*

Bacterial biofilms are the main aetiological component for periodontitis, removing them from the root surface is the cornerstone of the current strategy in treating the condition. *P. gingivalis* is a prominent component of these biofilms due to its pathogenic function in severe types of human periodontitis, which is linked to several metabolic characteristics and potential virulence factors [31]. Although a number of techniques have been developed to enhance the removal of calculus and biofilm, the aforementioned techniques remain the "gold standard". Research on new and alternative techniques is ongoing in an effort to develop cause-related therapy strategies that are more successful. Without making direct physical contact with the treated area, shock waves have the potential to remove bacterial biofilms from infected surfaces to a degree similar to that of an ultrasonic device, but they have less capability to remove calculus from the root surface [32].

#### **Conclusion**

Extracorporeal Shock Wave Therapy (ESWT) is a promising non-invasive modality in dentistry, particularly in periodontics, implantology and orthodontics. Its ability to stimulate tissue regeneration, reduce inflammation, enhance angiogenesis and modulate bone metabolism makes it useful in managing periodontal disease, improving osseointegration and implant stability and potentially accelerating orthodontic tooth movement with pain reduction. However, further research is required to clarify its mechanisms, optimize treatment protocols and evaluate long-term safety and efficacy through large-scale clinical trials. Overall, ESWT may serve as a valuable adjunctive tool in contemporary dental practice.

#### **Conflict of Interest**

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Not applicable.

#### **Ethical Statement**

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

## Informed Consent Statement

Informed consent was taken for this study.

## Authors' Contributions

All authors contributed equally to this paper.

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