REVIEW

EXTRACORPOREAL SHOCKWAVE THERAPY... "UNVEILING NEW HORIZONS IN PERIODONTOLOGY"- AN OVERVIEW

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ABSTRACT

The search for newer and efficient treatment modalities in the field of Medicine has always been on a rise, Dentistry being no exception to this trend. Extracorporeal shock wave therapy (ESWT) has been widely used in medical practice for management of various orthopaedic, musculoskeletal disorders, urolithiasis and cholilithiasis. The efficacy of extracorporeal shock wave therapy (ESWT) on enhancing bone regeneration, inducing angiogenesis, bactericidal effect, stimulation of osteoblasts, fibroblast cells and enhancing bone morphogenic protein (BMP) expression are noteworthy. The present paper reviews and explores the possibilities of application of (ESWT) in the field of Periodontics as well as inculcating its beneficial properties in improving treatment outcome.

KEY WORDS

Extracorporeal shock wave therapy (ESWT), bone regeneration, angiogenesis, analgesic, anti-inflammatory, bactericidal effect, biofilm, periodontal therapy, peri-implantitis.

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INTRODUCTION

Extra-corporeal shock wave therapy also referred to as "shockwave bio-surgery of sound", is a non-invasive treatment modality implementing shockwaves to treat chronic, painful conditions of the musculoskeletal system. The word "Extra-corporeal" means "outside the body" and also refers to the fact of shockwaves being generated outside the body.[1] Shock waves have been described as single high-amplitude sound waves generated by electrohydraulic, electromagnetic, or piezoelectric methods that propagate in tissues with a sudden rise from ambient pressure to its maximum pressure at the wave front, followed by lower tensile amplitude.[2] In simpler words, a shock wave is a transient pressure disturbance that propagates rapidly in three-dimensional space.

Shock waves utilize an sonic pulse characterized by a high peak pressure, a short life cycle, fast pressure rise and a broad frequency spectrum (Figure1) [International Society for Medical Shockwave Treatment].[3]

The machine used to generate shockwave allows the shockwaves to be focused and controlled such that the shockwaves get transmitted through the uninjured portions of the body unaffected, and deliver focused energy to a point at the level of the injured tissue. Initially, a mechanical pressure and tension force is generated on the afflicted tissue which increases the cell membrane permeability, thereby increasing microscopic circulation within the tissues as well as elevates metabolism within the treated tissues, both of which simultaneously promotes healing and dissolution of pathological calcific deposits. The extra corporeal shock wave therapy shock waves pressure front creates "cavitation bubbles" behind it, which are small empty spaces created behind the energy front. These cavitation bubbles tend to expand to a maximum size, then collapse violently which creates a resultant force that is strong enough to break down pathological deposits of calcification in soft tissues.[1]

HISTORICAL BACKGROUND

During 1980s Extracorporeal shock wave therapy (ESWT) was introduced in Germany. Ever

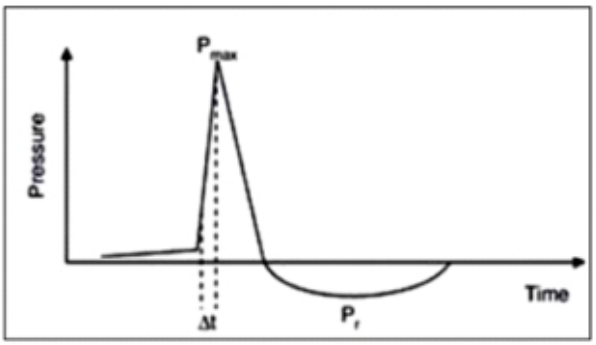

Figure 1. Characteristics of shockwaves. P_{max}=pressure maximum; P_1= negative peak pressure; Δt = pressure rise time

since its inception ESWT has been used for the management of urolithiasis, cholelithiasis and sialolithiasis.[4] Later on it was implemented for the treatment of dermal wounds, orthopedic conditions and musculoskeletal conditions. ESWT also demonstrated good analgesic effects and thereby specialized machines were improvised with the idea of utilizing these shockwaves on other parts of the body. A vast scope in the treatment of oral and maxillofacial conditions were identified later.[5]

CLINICAL APPLICATIONS OF ESWT-

ESWT in management of sialolithiasis

Amongst one of the common conditions affecting the salivary glands is sialolithiasis which refers to the 'calcified mass' that forms in the salivary gland, usually the wharton's duct of the submandibular gland. Sialo adenectomy commonly undertaken in such cases, carries the risks of damage to the vital structures in the vicinity. However, extra corporeal shock wave therapy has been employed as an alternative, especially in situations where the size of the calculi do not exceed 7 millimeter. The pressure pulses of the shock wave cause disintegration of the calculi by utilizing the phenomenon of cavitation and proves to be a safe, effective, minimally invasive, non- surgical treatment option. [6]

Application of ESWT in induction of bone Regeneration

Available literature supports the evidence that shock waves have a potential to induce bone regeneration with energy levels of 0.16 mJ/mm2 in a range between 250 and 500 impulses.[7] Also shock waves, seems to increase expression of osteogenic markers like bone morphogenic proteins (BMP), transforming growth factor (TGF-β), bone alkaline phosphatase activity and osteocalcin mRNA expression.[8] This property of bone regeneration of ESWT improved healing of experimentally induced mandibular sub-condylar fractures, where it showed to significantly improve the fracture healing scores.[9]

Anti-Inflammatory, analgesic and regenerative properties of ESWT

Notable reductions in levels of the inflammatory markers such as intercellular cell adhesion molecules (ICAM) and vascular cell adhesion molecules (VCAM) were evident significantly up to 1 month post treatment when Shock waves were applied at energy levels of 0.18 to 0.25 mJ/mm^2 at 400 to 500 pulses. As possible explanation to this anti-inflammatory phenomenon of ESWT it was attributed to the induction of nitric oxide and nitric oxide synthase production by shock waves under inflammatory conditions.[10]

Increased expression of angiogenic growth factors and angiogenic markers including vascular endothelial growth factor (VEGF) and endothelial nitric oxide synthase (eNOS), proliferating cell nuclear antigen (PCNA) were noted when shock waves were delivered at a dose of 500 impulses, with energy of 0.12 mJ/mm^2 over a duration of 20 min for the regeneration at the bone-tendon junction. ESWT induces cell proliferation and neo-vascular differentiation, thereby enhancing blood supply and in turn inducing tissue regeneration.[11]

The analgesic effect of shock waves was attributed to a reduced expression of calcitonin gene-related peptide (CGRP) in neurons related to the treated site as well as a reduction in the number of neurons immunoreactive to substance P.[12]

APPLICATIONS OF ESWT IN PERIODONTICS

Periodontitis is an immuno-inflammatory disease that leads to destruction of periodontal ligament and adjacent supporting alveolar bone and is induced by pathogenic sub-gingival microbial biofilms containing several periodontal pathogens. Loss of alveolar bone is a common sequel of periodontal disease. As discussed previously, the potential of shock waves to activate osteoblasts, osteogenic growth factors and their progenitors, induce and increase neovascularization and thus in the induction of new bone formation has been successfully applied in a study, where ESWT has successfully promoted regeneration of alveolar bone lost following experimentally induced periodontal disease. The degree of regeneration was noted to improve in accordance to the dose of ESWT applied. Also, the regenerative effect of ESWT seemed to last for a longer period with higher doses of 300 and 1000 pulses at energy flux density (EFD) of 0.1 mJ/mm [2.13] Hence, there exists a promising future in this field of periodontal regeneration and paves the way for future developments, where ESWT could prove to be a valuable adjunct.

Bactericidal efficacy of ESWT in general and in particular on oral bacteria and biofilm

Novak et al. 2008 conducted a study considering the efficacy of shock waves on oral bacteria

especially periodonto pathogens and reported that shock waves at low doses of 100 pulses at 0.3 mJ/mm^2 had a selective bactericidal effect on two bacterial species implicated in periodontal pathologies, particularly Streptococcus mutans and an unencapsulated strain of Porphyromonas gingivalis. Also a significant disruption of oral bacterial aggregates occurred with these low energy levels of shock waves whereas the viability of other microorganisms was not significantly affected by it.[14] Similar efficacy on disruption of bacterial biofilms from tooth surface was reported which was at par with ultrasonic instruments.[15] Extra corporeal shockwave therapy could break up the biofilm layers and disperse individual bacteria into surrounding tissues, leading to increased susceptibility to antibacterial agents and the access of antibiotics and inflammatory cells to avascular areas could be improved by neovascularization and tissue regeneration. No systemic spread of bacteria or other side effects have been documented so far.[16] Furthermore, these studies also concluded that infections should no longer be categorized as a contraindication for shock wave treatment.

ESWT in alveolar bone regeneration

Sathish kumar et al. 2008 conducted a study where rats were infected with strains of P. gingivalis for 10 weeks, which caused alveolar bone resorption. The rats were then treated with a single episode of 100, 300, or 1000 impulses of shock wave on both cheeks at energy levels 0.1 mJ/mm^2. Evaluation of alveolar bone levels were done at 0, 3, 6, and 12 weeks following extra corporeal shockwave therapy and were compared with those of controls. Significant improvement in alveolar bone levels was demonstrated in the infected rats treated with 300 and 1000 impulses at 3 weeks compared with untreated controls, and the improved levels remained for at least 6 weeks in most rats. These studies have demonstrated effective regeneration of alveolar bone by extra corporeal shockwave therapy and also suggests that this therapy could be used as an adjunct in the regeneration of periodontal tissues. [15]

ESWT in calculus removal

In order to explore the possibilies of utilizing shock waves for dental calculus and biofilm removal and hence, in the treatment of periodontitis Muller in 2003 conducted a study. shock wave device was modified and a hand piece was designed that could simulate the techniques that are employed regularly for calculus and biofilm removal. A reduced efficiency in calculus removal when compared to an ultrasonic instrument was observed in the study. However; the efficiency of biofilm removal was comparable with an ultrasonic instrument.[15] Further improvements in extra corporeal shockwave therapy equipment can provide a good treatment option for calculus removal and at the same time imparting an antibacterial action and disruption of bacterial biofilms, proving to be having a superior edge over conventional scalers to control periodontitis.

ESWT in peri implantitis

Peri-implantitis, a common complication of dental implants has a high incidence, which is detrimental to the longevity of the dental implants. The current treatment protocols of periimplantitis has its own limitations and it is hard to achieve optimal re-osseointegration. Studies have depicted that extracorporeal shock waves may activate osteoblasts and their precursors, and has a bactericidal effect on several oral pathogens. Hence, extra corporeal shockwave therapy might serve as an adjuvant treatment for non-surgical management of peri-implantitis by enhanced infection control, inducing alveolar bone regeneration and promoting reosseointegration.[17]

CONCLUSION

The prospects of ESWT as non-invasive treatment modality along with its antibacterial efficacy, having an inhibitory effect on the periodonto-pathogens, enhanced alveolar bone regeneration and rapid periodontal remodeling, combined with anti-inflammatory, analgesic and tissue-regenerative properties with very minimal or almost no documented side effects, back its potential to be implemented in periodontal therapy. However, time, cost factors and feasibility should be addressed with future studies and technical up-gradation of equipment. Also application of ESWT in periodontics needs to be worked on and would demand the development of suitable, cost-effective equipments. Several issues regarding extra corporeal shockwave therapy need to be addressed, such as, high versus low energy extra corporeal shockwaves, shockwave dosage and number of sessions required for a therapeutic effect.

Extra corporeal shockwave therapy is contraindicated in pregnancy and for people on medications namely Coumadin and prophylactic aspirin that interfere with blood clotting. Further, there is a paucity in documented evidence for the use of ESWT in the field of periodontics, and future research is anticipated for the introduction of this treatment strategy into routine practice.

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