Short Communication

Extracorporeal shock wave therapy in periodontics: A new paradigm

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Abstract:

The quest for exploring new frontiers in the field of medical science for efficient and improved treatment modalities has always been on a rise. Extracorporeal shock wave therapy (ESWT) has been enormously used in medical practice, principally, for the management of urolithiasis, cholelithiasis and also in various orthopedic and musculoskeletal disorders. The efficacy of ESWT in the stimulation of osteoblasts, fibroblasts, induction of neovascularization and increased expression of bone morphogenic proteins has been well documented in the literature. However, dentistry is no exception to this trend. The present article enlightens the various applications of ESWT in the field of dentistry and explores its prospective applications in the field of periodontics, and the possibility of incorporating the beneficial properties of shock waves in improving the treatment outcome.

Key words:

Alveolar bone, biofilm, dental calculus, periodontal therapy, shock waves

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INTRODUCTION

Shock waves are 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.[1] In simpler words, a shock wave is a transient pressure disturbance that propagates rapidly in three-dimensional space. It is associated with a sudden rise from ambient pressure to its maximum pressure. Shock waves utilize a sonic pulse characterized by a high peak pressure, a short life cycle, fast pressure rise and a broad frequency spectrum [International Society for Medical Shockwave Treatment (ISMST)].[2] The action of shock waves on tissues is by direct stresses associated with the high amplitude of shock waves, and the stresses and microjets associated with the growth and violent collapse of cavitation bubbles. The most important mechanical effects of shock waves are reflection with pressure and tension forces at the borders of different impedances and the generation of cavitation bubbles in liquids.[3] Extracorporeal shock wave therapy (ESWT) was introduced in Germany in 1980s. It has been used for the management of urolithiasis, cholelithiasis and sialolithiasis.[4,5] The principle was then extended to a wide arena of treatment modalities like treatment of dermal wounds,[6] orthopedic conditions[3,7-9] and various musculoskeletal conditions.[9,10] There appears a vast scope it merits in the treatment of oral and maxillofacial conditions.[9-13]

ESWT in the management of sialolithiasis

Sialolithiasis is one of the common conditions affecting the salivary glands. Surgical procedures involving incision of the salivary gland duct followed by removal of the stone and/or sialo-adenectomy are commonly undertaken, carrying the risks of damage to the vital structures in the vicinity. However, as an alternative, ESWT has been employed, especially in situations where the size of the calculi do not exceed 7 millimeter.[10] The pressure pulses of the shock wave release shearing forces and cavitation energy that cause disintegration of the calculi.[11] Hence, they can prove to be a safe, effective, minimally-invasive, non-surgical treatment option for sialolithiasis.[10]

Application of ESWT in induction of bone regeneration

Several studies have strongly backed the evidence that shock waves have a potential to induce bone regeneration with energy levels of 0.16 mJ/mm^2 in a range between 250 and 500 impulses.[12-17] Following the treatment of the orthopedic sites with shock waves, it was noted that there was an increased expression of osteogenic markers like bone morphogenic proteins (BMP),[13] transforming growth factor (TGF-β),[15] increase of bone alkaline phosphatase activity[18] and osteocalcin mRNA expression.[18] This property of bone regeneration of ESWT was also extended for improved healing of experimentally induced mandibular sub-condylar fractures, where it showed to significantly improve the fracture healing scores. Hence, it was concluded that ESWT combined with intermaxillary fixation can be an effective therapy for accelerated fracture healing and even for reduction in the incidence of complications associated with fracture healing.[19]

Anti-Inflammatory, analgesic and regenerative properties of ESWT

Shock waves seem to have an anti-inflammatory,[20-22] tissue regenerative[22,23] and analgesic effect on tissues.[24-26] When applied at energy levels of 0.18 to 0.25 mJ/mm^2 at 400 to 500 pulses to evaluate the anti-inflammatory effects on osteonecrosis of femoral head, it showed that the levels of the inflammatory markers such as intercellular cell adhesion molecules (ICAM) and vascular cell adhesion molecules (VCAM) were significantly reduced up to 1 month after treatment.[22] A possible explanation to this anti-inflammatory phenomenon could be an induction of nitric oxide and nitric oxide synthase production by shock waves under inflammatory conditions.[20,21] When applied for the regeneration at the bone–tendon junction, at a dose of 500 impulses, with energy of 0.12 mJ/mm^2 over a duration of 20 min, the shock waves appeared to increase the expression of angiogenic growth factors and increased expression of angiogenic markers including vascular endothelial growth factor (VEGF) and endothelial nitric oxide synthase (eNOS), proliferating cell nuclear antigen (PCNA) that induces cell proliferation and neo-vascular differentiation, thus improving blood supply and in turn inducing tissue regeneration.[23] Various studies have documented the mechanism of analgesia by shock waves. One such study on the effect of shock waves on musculoskeletal system confirmed that shock waves induced selective partial denervation brought about by significant loss of unmyelinated nerve fibers in relation to treated limb.[24] Some of the other mechanisms stated for the analgesic effect of shock waves include a reduced expression of calcitonin gene-related peptide (CGRP) in neurons related to the treated area,[25] and a reduction in the number of neurons immunoreactive to substance P,[26] thereby bringing about analgesic effect. The application of ESWT during orthodontic treatment showed that shock waves induce increased IL-1beta production as part of mechanical forces transduction, thus triggering a biologic response. This in turn could contribute to accelerated periodontal remodeling and hence foreshortening of the orthodontic tooth movement period.[27,28]

APPLICATIONS OF ESWT IN PERIODONTICS

The documented evidence on the use of ESWT in periodontics, however, is very limited. 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.[14] Loss of alveolar bone is a common sequel of periodontal disease. As mentioned earlier, 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 proved to successfully promote regeneration of alveolar bone lost following experimentally induced periodontal disease.[14] In addition, 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.[14] Hence, there exists a scope for further studies to pave the way for future developments in this field of periodontal regeneration, where ESWT could prove to be a valuable adjunct.

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

The use of ESWT in destruction of bacteria has been a question of debate. Various studies conducted to evaluate the bactericidal efficacy of shock waves in destruction of bacteria have given controversial results. One such study showed that shock waves at high energy levels have a lethal effect on bacteria,[29] while other studies concluded that the microorganisms continued to persist and cause inflammation in the sites treated with shock wave.[14,30] A study considering the efficacy of shock waves on oral bacteria especially periodonto-pathogens reported that shock waves at low doses of 100 pulses at 0.3 mJ/mm^2 had a selective bactericidal effect on two commonly detected bacterial species implicated in periodontal pathologies, particularly *Streptococcus mutans* and an unencapsulated strain of *Porphyromonas gingivalis*. In addition, it showed that a significant disruption of oral bacterial aggregates occurred with these low energy levels of shock waves and that the viability of other microorganisms was not significantly affected by it.[31] Similar results on disruption of bacterial biofilms from tooth surface have also been reported where-in the potential of shock waves was at an at par comparison levels with ultrasonic instruments.[32] Also, the use of ESWT at sites of active infection has been a controversial belief. However, clinical trials and studies have documented no systemic spread of bacteria or other side effects.[29,33] Furthermore, these studies concluded that infections should no longer be generally classified as a contraindication for shock-wave treatment and suggest this option in the management of difficult-to-treat infections.

ESWT in the management of peri-implantitis

Peri-implantitis is found to be a common and a chief problem affecting the longevity of an implant. It has been hypothesized that a combination of all the beneficial effects of ESWT could be creatively utilized in the non-surgical management of peri-implantitis. Hence, ESWT can be used as an adjuvant, owing to its bone regeneration and anti-bacterial properties, thereby promoting re-osseointegration and improving the success rates of implants.[34]

ESWT in dental calculus removal

It would be noteworthy that a study was conducted to explore the possibility of utilizing shock waves for dental calculus and biofilm removal and hence, in the treatment of periodontitis. The authors modified the shock wave device and designed a hand piece that could simulate the techniques that are employed regularly for calculus and biofilm removal. The study concluded that ESWT had a reduced efficiency in calculus removal when compared to an ultrasonic instrument.[32] However, the efficiency for biofilm removal was comparable with an ultrasonic instrument. This has paved the way for the possibility of development of equipment modified suitably for the purpose of dental calculus removal. When this is achieved, ESWT would prove to be a good treatment option having a superior edge over conventional scalers to control periodontitis both from the aspect of effective total debridement to imparting an antibacterial action and disruption of bacterial biofilms.

CONCLUSION

With the limited, yet supporting literature on the advantages of shock waves, there exists a motivating evidence that implementation of the beneficial properties of shock waves with suitable modifications in the periodontal arena can prove to be a valuable modality in enhancing the treatment outcome. The prospects of this non-invasive treatment modality with its antibacterial efficacy, especially to the periodonto-pathogens, potential to induce alveolar bone regeneration and rapid periodontal remodeling, combined with anti-inflammatory, analgesic and tissue-regenerative properties with minimal or no documented side effects, provide a substantial backing for its potential to be implemented in periodontal therapy. However, time and cost factors are issues of concern that can only be clarified with future studies and technical up-gradation of equipment. The available information is clearly suggestive of its development into this field in infancy stages and further studies are required to substantiate the practical application of its benefits and features for a continuation of its successive path into the future. Also, the economics of the feasibility of application of ESWT in periodontics needs to be worked on and would depend on the development of suitable, cost-effective equipment. Further, as documented evidence for the use of ESWT in the field of periodontics is meager, future research is anticipated for the introduction of this treatment strategy into routine practice.

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