Research Article

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Effect of Low-Intensity Pulsed Ultrasound on Orthodontically Induced Root Resorption Caused by Orthodontic Treatment: In Vitro Study

Sankha Biswas[1*] Shubhosri Sarkar[2] Ananya Biswas[3]

[1]Professor, Department of Orthodontics and Dentofacial Orthopaedics, Haldia Institute of Dental Sciences and Research, Haldia, India.
[2]PG Student, Department of Orthodontics and Dentofacial Orthopaedics, Haldia Institute of Dental Sciences and Research, Haldia, India.
[3]Professor and Head, Dental Department, JNM Medical College & Hospital, Kalyani, India.

ABSTRACT

Background: **Objectives:** To evaluate the effects of low-intensity pulsed ultrasound (LIPUS) on orthodontically induced tooth root resorption caused by torque in human subjects.

Materials and Methods: Ten healthy patients (12–35 years of age) who required extraction of all first premolars as a part of their routine orthodontic treatment were recruited. A 15u twist was applied in the arch wire using 0.019 3 0.025-inch TMA in a 0.022-inch bracket system (Synergy R) that produced a buccal root torque of approximately 5 N/mm at the bracket level. Using a split mouth design, randomization, and blinding, one side of the arch received LIPUS for 20 minutes per day for 4 weeks at an incident intensity of 30 mW/cm2 of the transducers' surface area. The other side served as a self-control, which received a sham transducer. After 4 weeks, all first premolars were extracted and micro–computed tomographic analysis was performed on these extracted teeth. A linear mixed-model statistical analysis was used.

Results: LIPUS-treated teeth showed significantly less total volume of resorption lacunae compared to control teeth by a mean difference of (0.54 6 0.09 mm3) (P , .001) and percentage of root resorption by a mean difference of (0.33 6 0.05 mm3) (P , .001). In addition, significantly fewer resorption lacunae were found on all root surfaces in the LIPUS group compared to the control except in the instance of the distal surface.

Conclusions: LIPUS minimizes root resorption when applied during torque tooth movement over a 4-week period.

Keywords: Orthodontic root resorption; Torque; Low-intensity pulsed ultrasound; LIPUS.

INTRODUCTION

Orthodontically induced root resorption (OIRR) is an unavoidable consequence of orthodontic treatment. The incidence of OIRR is greater than 90%, and the prevalence of minor to severe OIRR ranges from 94% to 6.6%, respectively. There are many potential treatments for OIIRR. but the only reported clinically acceptable modality is low-intensity pulsed ultrasound (LIPUS)[1-2].

Mechanism:

LIPUS is acoustic pressure waves that can stimulate a variety of cells including cementoblasts, odontoblasts, osteoblasts, chondrocytes, gingival cells, and periodontal ligament cells[3]. Lipus promotes cementogenesis by increasing the alkaline phosphate (alp) activity, collagen-i synthesis, and

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*Correspondence Dr. Sankha Biswas.
Department of Orthodontics and Dentofacial Orthopaedics, Haldia Institute of Dental Sciences and Research, Haldia, India.
Email: biswas.sankha2012@gmail.com

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runx-2 protein in cementoblasts and inhibits cementoclastogenesis[4].

Other uses: LIPUS serves as a potential noninvasive therapeutic procedure for bone fracture healing, LIPUS exposure accelerates orthodontic tooth movement. LIPUS exposure reduced the atrophic change of PDL structure and upregulated periostin and CTGF transcriptional levels to promote PDL healing[5-6].

Material and method:

The study participants consisted of 12 healthy individuals, two males and 10 females, with an average age of 15.5 ± 5.48 years at the beginning of the study. They were scheduled to receive orthodontic treatment and extraction of all of their first premolars as a part of their orthodontic treatment[7].

STUDY DESIGN:

Study design was a prospective, split-mouth, double-blinded, randomized, controlled clinical trial. For each patient, Nance holding arch and mandibular lingual arch were delivered to support the first molars (anchorage)[8]. All first premolars were bonded with Synergy-R brackets (0.022-inchg slot size) (RMO, Denver, Colo) in a passive position using 0.021× 0.025-inch wires to ensure that they were at zero torque at the bonding[9].

Fig 1: Nance holding arch.

Torque application

Next, a 15^0 twist was applied in the sectional 0.019× 0.025-inch wire (Titanium Molybdenum Alloy, RMO) connecting the first premolar and first molar on each side[10]. Producing clinically appropriate buccal root torque at the premolar bracket level of approximately 5 N/mm[11-12].

Fig 2: Mandibular lingual arch.

Blinding

Both the upper and lower first premolars on one side were randomly assigned to receive active LIPUS transducers, while the other side's premolars received sham transducers[13-14]. Before the start of the study, inactive and active LIPUS transducers were blinded and coded but were marked "right" or "left"[15-16]. The clinician, the study coordinator, the patient, and the outcome assessor all were blinded to the active and control sides[17].

Lipus application

LIPUS was applied using a custom-made ultrasound device (SmileSonica Inc, Edmonton, Alberta, Canada)—for 20 minutes per day for 4 weeks[18-19]. The patients were instructed to apply the ultrasound transducer to in the muco-buccal fold[20]. Intraoral ultrasound gel was used to couple the ultrasound energy between the transducer and the gum[21].

Lipus parameters

The LIPUS parameters used in this study were 200-ms-wide pulses that each had a frequency of 1.5 MHz and a pulse repetition frequency of 1 kHz , intensity of 30 mW/cm2 of the transducer's surface area[22].After 4 weeks all of the first premolars were extracted, then they were scanned in a SkyScanH (1076) micro-CT scanner at a resolution of 9 mm. Resorption lacunae (RL) were analyzed over the whole length of the roots starting at the cemento-

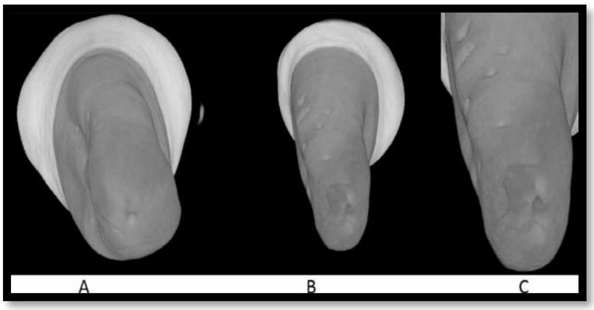

Fig 3: Three dimensional illustration of the micro-CT image of mandibular premolar showing root resorption caters[A]LIPUS treated premolar[B]conrol premolar[C]Root resorption cater

RL COUNT

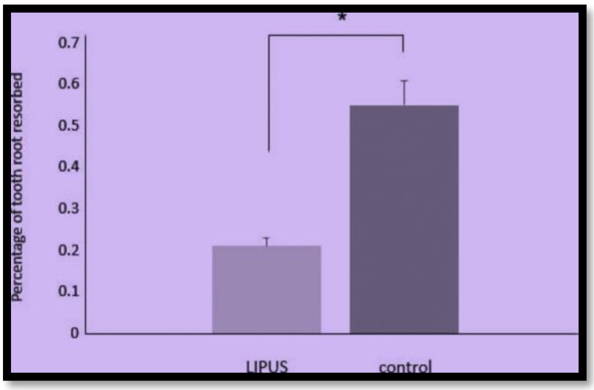

Fig 4: Micro-CT analysis of percentage of tooth root resorped(mean+/-SE)in LUPUS and control group(*=p<0.05)

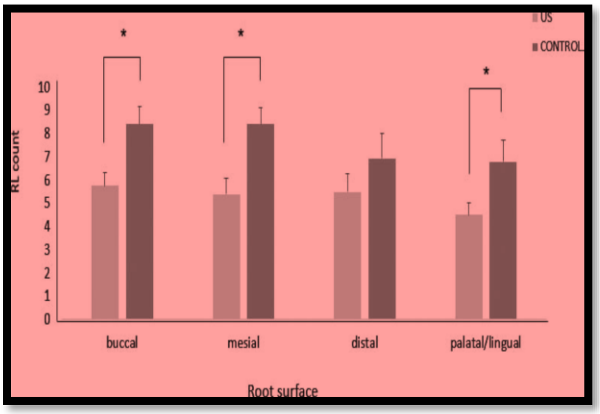

Fig 5: Micro-CT analysis of RL count(mean+/-SE) on different root surfaces in LUPUS and control group(*=p<0.05)

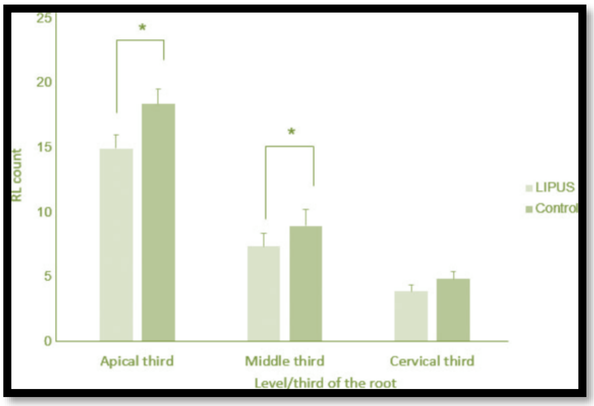

Fig 5: Micro-CT analysis of RL count(mean+/-SE)at different level /third of the root in LUPUS and control group(*=p<0.05)

enamel junction and proceeded to the root apex[23]. Location, number, height, and volume of RL were calculated.

RESULTS

The result of the study demonstrated that LIPUS significantly decreased root damage compared to the control group.

The results of this study demonstrated that LIPUS reduced the total volume of RL and percentage of root resorption by more than 50% during clinically relevant torque tooth movement[24]. Anabolic effect of LIPUS on cementoblasts that either helped repair RL or stimulated secretion of a protective cementum layer against OIRR. LIPUS can inhibit osteoclast activity by decreasing the Receptor activator of nuclear factor kappa-B ligand/Osteoprotegerin (RANKL/OPG) ratio.

CONCLUSION

The present clinical trial, it can be concluded that daily application of LIPUS for 20 min/d for 4 weeks significantly reduced the severity of OIRR caused by torque in humans[25].

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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