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Impact of Low-Level 660 nm Laser Therapy on Nano-Hydroxyapatite Bone Graft for Preserving Post-Extraction Socket Width

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Aim: This study seeks to ascertain if nanohydroxyapatite laser treatment can preserve alveolar bone width following tooth extraction.
Materials and methods: After selecting thirty patients, a random allocation among three equal groups was conducted. In group I, the empty socket was sealed with a bioresorbable collagen membrane lacking a grafting material following tooth extraction. In group II, nanohydroxyapatite was introduced into the socket post-tooth extraction, followed by placing a bioresorbable collagen membrane over the graft, which was subsequently sutured. In group III, nanohydroxyapatite was introduced into the socket post-extraction, and a bioresorbable collagen membrane was applied over the grafting material and sutured. Subsequently, low-level 660 nm laser therapy (LLLT) with a power of 25 mW and duration of 120 seconds was administered thrice weekly for 2 weeks. The alveolar bone's breadth was assessed. by CBCT immediately post-surgery, as well as at 3 months and 6 months thereafter.
Results: The NHA and LLLT groups exhibited a minimal reduction in width measures.
Conclusion: Low-level 660 nm laser therapy (LLLT) to alveolar sockets decreased bone resorption six months post-bone grafting by NHA.

Keywords: Laser Biostimulation, N-Hydroxyapatite, Cone Beam Computed Tomography, bone resorption.

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Introduction

Upon extracting any tooth, the alveolus typically undergoes resorption. Alveolar resorption is the remodeling process following a tooth extraction, potentially resulting in bone loss rates of up to 50%, with horizontal bone loss typically being more pronounced than vertical bone loss.[1]

Alveolar ridge preservation strategies have been suggested to avert this resorption process. After extraction, graft materials, autogenous bone, or biological materials are inserted inside the empty socket.[2–6]

Alveolar ridge preservation techniques can mitigate bone loss. Nevertheless, they do not entirely prevent it.[7-9]

The LLLT technique is utilised in the dental field based on the premise that laser photo biostimulation reduces inflammation, mitigates discomfort, and decreases oedema. The passage of time facilitates wound healing and tissue regeneration.[10-15]

Components of the mitochondrial respiratory chain are capable of absorbing laser radiation. LLLT elevates ATP levels, enhances protein synthesis, stimulates proliferation expression, and boosts growth factors and cytokines.[16]

Diode lasers emitting at 904 nm and 660 nm have impacted bone repair and enhanced osteoblastic activity.[17,18] It has also been utilised to stimulate osseous development in dental extraction sites. [19-21] Numerous investigations indicated that NHA exhibits significant bioactivity, angiogenic characteristics, minimal toxicity, and no inflammatory or antigenic responses.[22] Its compositional resemblance to normal bone most effectively establishes the mechanism underlying NHA's regenerating capacity.[23, 24]

Furthermore, osseous tissue can adhere to HA, resulting in the deposition of new bone.[25]

The surface of HA has been verified to enhance osteoblasts' adhesion, proliferation, and differentiation.[26] The authors assert that nano-hydroxyapatite exhibits comparable surface roughness, hydrophilicity, and an increased surface area relative to natural hydroxyapatite, leading to biological effects including enhanced protein adsorption, mesenchymal cell adhesion, differentiation, and cell proliferation. Moreover, it exhibits significant resorption and can be substituted by osseous tissue.[27,28]

This study aims to reveal the LLLT technique's impact on hydroxyapatite (HA) implantation after dental extraction to conserve the alveolar bone socket.

Materials and methods

Thirty human cases were chosen for this study after applying the criteria of inclusion and exclusion from the Oral and Maxillofacial Surgery Outpatient Clinic of Kobri El Koba Military Hospital. After signing an informed consent form detailing the procedure and anticipated treatment outcomes, they were allocated into three groups.

Inclusion Criteria

- Adult patients aged 20 to 40 years in good health.
- Unrestorable teeth or remaining roots necessitating extraction.
- Inferior premolars and molars.

Exclusion Criteria

- Individuals with systemic illnesses.
- Severe infection.
- Individuals who smoke excessively.
- Women who are lactating or pregnant.

Sample size

Sample size calculated depending on a previous study (width). The findings indicated a minimum sample size of n = 30 samples, (10 for each) when the power was 80 % & type I error probability was 0.05. Sample size was performed by ANOVA test using G.Power version 3.1 statistical software, Franz Faul, Universität Kiel Germany version 3.1 statistical software, Franz Faul, Universität Kiel Germany.

F tests - ANOVA: Fixed effects, omnibus, one-way
Analysis: A priori: Compute required sample size
Input: Effect size f = 0.6349793
α err prob = 0.05
Power (1-β err prob) = 0.80
Number of groups = 3
Output: Noncentrality parameter λ = 12.0959613
Critical F = 3.3541308
Numerator df = 2
Denominator df = 27
Total sample size = 30
Actual power = 0.8456967

The thirty patients were randomly allocated into three groups based on their treatment regimen:

Group I: Ten patients received the extraction of extremely carious teeth, following which the extraction socket was coated with an absorbable collagen membrane (OsseoSeal, Avtec Surgical, USA) and secured with Vicryl 4-0 sutures (Ethicon, USA).

Group II: Ten patients had extremely carious teeth extracted, followed by introducing nanohydroxyapatite (IngeniOs HA, USA) into the extracted tooth socket. Subsequently, an absorbable collagen membrane was adopted and sutured to the grafted area.

Group III: Ten patients underwent extraction of extremely carious teeth, after which nanohydroxyapatite was placed in the extracted tooth socket, sutured with an absorbable membrane, and subsequently treated with the LLLT technique.

A surgical procedure was performed under local anaesthetic (4% Arti-Dent, Ahmedabad-380015, India). The highly carious mandibular molars or premolars were extracted in all three groups with utmost care to prevent soft tissue injury and bone resorption.

The alveoli were enveloped with a membrane and sutured in the first group. In the second group, nanohydroxyapatite was inserted into the extraction cavity, after which a bioresorbable collagen membranous material was affixed over the grafting substitute and sutured in place. [Figure 1]. In the third group, NHA was applied and covered with a membrane before suturing, utilizing 660 nm LLLT (three times weekly for two weeks at a power of 25 mW and duration of one hundred twenty seconds on buccal, lingual, and occlusal surfaces) with the Sirolaser Advance Plus (Dentsply Sirona, GMBH, Germany) [Figure 2].

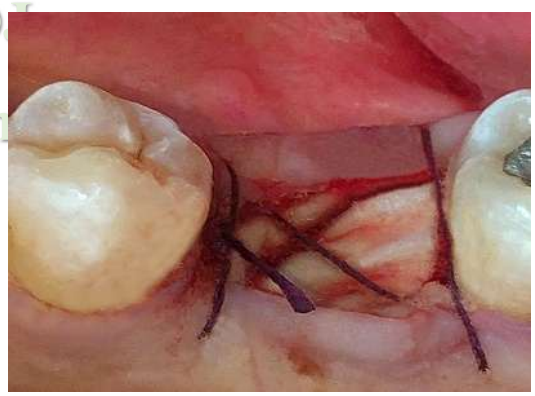

Figure 1: alveolar socket after grafting with NHA & suturing.

Figure 2: sirolaser advance plus

Radiographic

CBCT was conducted to assess the alveolus width as follows:
Alveolar breadth is the length between two reference lines drawn from the base of the jaw to the summit of the alveolus from the lingual and buccal sides. The reference line was positioned at the inferior margin of the mandible. [Figure 3]

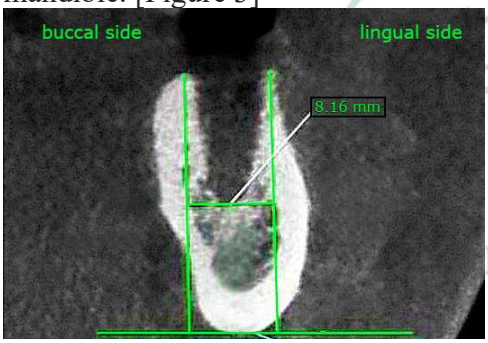

Figure 3: Coronal view Cone Beam CT showing alveolar bone width measurement.

Results

The statistical examination

The data was loaded onto a computer and handled with IBM SPSS software version 20.

Table 1: Showing mean bone socket width for all groups immediately, 3 months, and 6 months post-extraction and the significance level of the differences between them.

Group	Group I N=10	Group II N=10	Group III N=10	H	P
Bone socket width	Mean ± SD	Mean ± SD	Mean ± SD		
Baseline	7.34 ± 0.73	6.75 ± 1.09 [a]	7.93 ± 1.14 [a]	6.65 3	0.036*
3 months	6.08 ± 0.069	5.86 ± 1.11	7.09 ± 1.23	5.63 1	0.060
6 months	5.44 ± 0.59	5.20± 1.02 [b]	6.51 ± 1.19 [b]	8.10 1	0.017*

H: Kruskal Wallis test.
P: p-value between the studied groups.
*: Statistic significance at $p \leq 0.05$.
[a, b]: The same superscript letter in the row means a statistically significant difference.

Demographic information

The 30 patients were evenly distributed into three age groups: Group I consisted of individuals aged 21.0-39.0 years (mean age 31.20 ± 5.75 years), Group II included those aged 21.0-37.0 years (mean age 28.20 ± 4.92 years), and Group III comprised participants aged 22.0-38.0 years (mean age 29.50 ± 6.04 years). No difference of statistical significance was seen in the mean age between the groups.
Group I comprised 5 males and 5 females, Group II comprised 6 males and 4 females, and Group III comprised 4 males and 6 females. No difference of statistical significance was observed in the gender distribution among groups.

Radiographic (Bone Fossa Width)

The average width of the bone fossa decreased in all groups after six months. At each follow-up, group III had the greatest alveolar bone width (indicating minor resorption), while group I demonstrated

the least. The differences were statistically significant across all follow-up intervals. At three months, no statistically significant differences were seen. Pairwise statistical comparisons showed that the only significant differences between groups II and III occurred at baseline and the 6-month follow-up intervals.(Table 1)

Discussion

Bone repair is a multifaceted process involving cell metabolism, bone mineralization, and remodeling to reestablish the original structure.[29] A variety of investigations were undertaken to improve those troublesome systems.[30] Resorption after extraction is inevitable; however, its extent can be limited by applying membranes and bone graft materials. Research indicates that using bone grafts in filling extraction sockets significantly diminishes the resorption relative to natural healing through blood coagulation.[31]

Diverse chemicals may be employed to preserve the ridge post-extraction. All grafts necessitate adequate blood circulation, mechanical stability, osteoblastic cells from the host, grafting material, or a combination of both for optimal outcomes. Graft materials may possess osteo-conductive, osteo-inductive, or osteo-genic properties. Osteo-conductive materials function as a scaffold, facilitating the penetration and migration of surrounding cells.[32]

A radiologic and Histological study evaluated Allogenic Bone graft Blocks in Bounded Anterior Molar Alveolar Ridge Defects. The study results showed significant bone width and volume increases after 6 months of follow-up. Histologic analysis revealed new bone formation with minimal fibrous tissue formation.[33]

A clinical study evaluated maintaining the alveolar height and width post-teeth extraction with Nano-hydroxyapatite bone graft. Poly-lactide-co-glycolide (PLG) polymer (Fisiograft) showed the least resorption in socket width and increased bone density, so it decreased bone resorption after 6 months of grafting.[34]

This study utilized NHA as a bone graft, both with and without LLLT at 660 nm, 25 mW, administered for 120 seconds on buccal, lingual, and occlusal surfaces three times weekly for two weeks to assess bone regeneration and width following tooth extraction.

Our findings indicated that the NHA and LLLT groups had the least disintegration in width measurements.

The laser intervention was significantly more effective in augmenting the quantity of osteocytes within the irradiated area, indicating a high potential for new bone production.[35] The LLLT technique has been demonstrated in cellular cultures and animal studies to promote osteoblast proliferation and differentiation.[36]

Brawn et al.[37] examined the effects of near-infrared (NIR) laser phototherapy to assess regeneration of bone. Where, Bilateral extraction sockets were augmented with artificial HA particles. OsteografLD300 (Dentsply Friadent CeraMed, Lakewood, CO), one was subjected to phototherapy and the other was left untreated. The histological assessment of both sites revealed that the phototherapy-treated sites exhibited increased bone development and accelerated particle resorption related to the untreated sites.

Brawn et al.[38] performed a research study investigating the impact of LED phototherapy on a sinus augmented with granular bovine bone tissue (xenograft).

Phototherapy was administered bi-daily for 10 minutes per session for two weeks, utilising a 20 mW/cm² 620 nm Light Emitting Diode (LED). A biopsy was histologically examined after four weeks, demonstrating a vigorous healing response to the LED phototherapy.

Another study analyzed the effects of photobiomodulation therapy (PBM) on the repair process of experimentally produced bone defects in the tibia of rats, filled with mineralized inorganic bone matrix associated with fibrin biopolymer. The results demonstrated that the groups with low-level laser PBM presented the highest percentages of new bone formation, contributing to the repair of defects, especially at 42 days.[39]

Numerous in vivo and invitro investigations indicate that laser treatment enhances bone regeneration solely during the initial weeks (2 to 4 weeks) following a fracture. No discernible advantage over the control is apparent after 60 days.[40] That suggests that LLLT is effective solely in the initial phases of the process.

The limitations

The duration of observation in this investigation may be limited.

Conclusions

Within the constraints of this investigation, the utilization of LLLT on NHA graft material diminished bone width resorption in the alveolar socket after 6 months, indicating its efficacy in preserving the ridge post-tooth extraction.

Recommendations

Future research may necessitate histological examination.

Additional research is required to examine the effects of LLLT and NHA over an extended observation period of 12 to 24 months.

Declaration

Funding

This research was self-funded by the authors.

Data availability

All data related to this research were collected from the participants by using the CBCT which enabled to record their bone density measures after treatment.

Ethics approval

Ethical approval reference: NILES – EC – CU 24/10/16 moreover a consent was recorded in a written form that met the ethical guidelines set forth by the institutional ethics committee and understood by each participant.

Competing interests:

No conflict of interest

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