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Evaluation of the effect of low-level diode laser therapy applied during the bone consolidation period following mandibular distraction osteogenesis in the human

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Abstract. The aim of this study was to evaluate the effect of low-level laser therapy (LLLT) on new bone formation obtained by distraction osteogenesis in the early consolidation period. Ten selected patients with bilateral mandibular retrusion seen at the Nasser Institute Hospital, Egypt between June 2009 and June 2012 underwent this clinical trial; seven were female and three were male, and their mean age was 31 ± 5.1 years. The left mandible of each patient was assigned to group A ($n = 10$) and the right mandible to group B ($n = 10$); mandibular distraction osteogenesis was performed on both sides and then LLLT was used in group B only. The amounts of bone acquired were compared according to their radiographic density on digital panoramic radiographs after 6, 12, 24, and 54 days of consolidation. Statistically significant differences in bone density were found between the two groups. Group B showed bone consolidation and growth differences on day 6 ($P = 0.402$), day 12 ($P = 0.006$), day 24 ($P = 0.021$), and day 54 ($P = 0.028$). The use of LLLT on distracted bone was found to increase the quality and quantity of bone and to shorten the consolidation period, allowing early removal of the distractor and resulting in decreased morbidity and relapse.

Keywords: low-level laser therapy; consolidation period; distraction osteogenesis.

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Distraction osteogenesis (DO) is a technique for inducing new bone formation. After an osteotomy or corticotomy, the bony segments are separated and then gradual tension is applied to the callus connecting the separated bony segments using an external or internal fixation device, thereby lengthening the bone. This is followed by a consolidation phase in which the bone continues to heal.[1]

DO has become an increasingly used alternative method for facial bone reconstruction, with promising results. However, the long-term stability of the results obtained with DO only is not well documented, and reports of instability and relapse can be found in the literature.[2,3]

The gradual tension applied to the fracture gap activates the transformation of mesenchymal cells into osteoblasts and fibroblasts secreting type I collagen, which is organized into fibrils.[4] The periosteal and endosteal surfaces on either side of the fracture gap are rapidly revascularized, and woven bone extends rapidly into the collagen fibrils. This inter-zone remains relatively avascular, but becomes vascularized and mineralized rapidly once distraction ceases during the consolidation phase.[5,6]

Previous research aimed at increasing the quality and quantity of the newly formed bone obtained by DO, using supplements that promote osteogenesis such as hyperbaric oxygen or low-level laser therapy (LLLT), has been performed only in experimental animals. This research has sought to enhance the new bone growth and maturation in order to shorten the DO period by decreasing the duration of application.[1,7]

LLLT has been shown to be effective in wound healing, collagen synthesis, matrix deposition, angiogenesis, epithelialization, and osteogenesis.[8,9] LLLT increases osteogenesis by activating osteoblasts, increases the quality and quantity of bone that is augmented by DO, and reduces the time to maturation, with a marked reduction in osteoclast maturation and action.[10–12]

The effect of DO in combination with LLLT has been evaluated only in experimental animals and has been shown to increase both bone mineral density and torsional strength by many authors (Table 1).[2,10,13–17]

Taking into account the reported positive influences of LLLT on experimental mandibular DO, it was decided to investigate the potential effect of a diode laser (905 nm) on the process of bone regeneration during the consolidation phase after human mandibular DO, with the aim of reducing the duration of distraction and thus the complications associated with a long-term distractor device.

Patients and methods

The clinical trial design and protocol of this study were approved by the research ethics committees of Nasser Institute Hospital and Salman Bin Abdulaziz University. All patients underwent surgery in the Oral and Maxillofacial Surgery Department of the Nasser Institute Hospital in Cairo, Egypt.

Ten patients with bilateral mandibular retrusion were selected; seven were female (70%) and three were male (30%), and their mean age was 31 ± 5.1 years (range 18–46 years). These patients were seen over a 3-year period, from June 2009 to June 2012. The patients were treated under the guidelines of the hospital after they had been informed of the risks and benefits of the planned procedures. All provided written

Table 1. Experimental studies showing the effects of LLLT on distracted mandibles.

Study [Ref.]	Type of animal	Type of laser used	Method of assessment	Conclusion
Miloro et al. (2007)[10]	Adult female New Zealand white rabbits ($n = 9$)	GaAlAs – 820 nm	Radiographs using a bone healing score; histological examination using H&E dyes	LLLT accelerated the process of bone healing during the consolidation period
Cerqueira et al. (2007)[13]	Sheep ($n = 18$)	GaAlAs – 830 nm	Microscopic analysis using H&E dyes	The laser was more favourable when used in the consolidation period, after bone elongation
Hübler et al. (2010)[14]	Adult male New Zealand rabbits (*Oryctolagus cuniculus*) ($n = 5$)	GaAlAs – 830 nm	X-ray fluorescence spectroscopy	LLLT had a positive effect on the regeneration of newly formed bone
Kreisner et al. (2010)[15]	Adult male New Zealand rabbits (*Oryctolagus cuniculus*) ($n = 10$)	GaAlAs – 830 nm	Microscopic analysis using H&E dyes	LLLT had a positive effect on the quality of bone sites, allowing early removal of the distractors, and consequently reducing the total treatment time
Freddo et al. (2012)[2]	Female Corriedale sheep ($n = 5$)	GaAlAs – 830 nm	CT imaging	LLLT provided numerous benefits when applied during the bone consolidation period, as it promoted an increase in hardness and modulus of elasticity values
De Conto et al. (2013)[16]	Male New Zealand white rabbits (order *Lagomorpha*, genus *Oryctolagus*, species *O. cuniculus*) ($n = 24$)	GaAlAs–830 nm	Microscopic analysis using H&E dyes and histomorphometric analysis	The application of LLLT following the irradiation protocol used in this study had a positive effect on the tissue repair process in a rabbit model of mandibular fracture and distraction
Kan et al. 2014[17]	Female New Zealand white rabbits ($n = 16$)	GaAlAs–808 nm	Micro-CT analysis; analysis of plain radiographs; histology and histomorphometry	LLLT application in the distraction period activated bone healing; LLLT may decrease the distraction period

LLLT, low-level laser therapy; H&E, haematoxylin and eosin; CT, computed tomography.