


Research Article

Problems and Perspectives on Accelerated Orthodontic Tooth Movement by Low-Level Laser Photobiomodulation

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The low quality of evidence on photobiomodulation (PBM) effectiveness in orthodontics has been reported in recent reviews and in the Editorial by Marques [1-6]. The topic is a burning one, due to the high prevalence (64.4%; 38/59 systematic reviews) of exaggerated claims in the abstracts of systematic reviews (SR) related to accelerated orthodontic tooth movement (OTM) [1]. Taking into account the selected SR, the majority of SR claims (37.2%; 22/59 SR) came under the misleading reporting category, while 16.9% came under the misleading interpretation category (10/59 SR) and 10.2% (6/59 SR) under the misleading extrapolation category [1]. We observed a remarkable prevalence (13.6%; 8/59) of SR, with exaggerated claims concerning PBM therapy. We agree that the lack or low quality of evidence on PBM effectiveness is mainly caused by the: a) wide heterogeneity of both laser and treatment parameters, b) different irradiation protocols (from a single application to repeated applications), c) lack of specific parameters in orthodontic practice, d) limited evidence about the adverse effects of PBM therapy [2-6].

Nevertheless, we think that there are other weaknesses of the research that impair obtaining firm evidence and reproducible studies, and therefore clearer clinical indications for orthodontists.

Weaknesses of research relates to:

- **OTM treatment time.** Shortening treatment time is a priority for orthodontists and adult patients. Operator-related factors and skill level seem to be more important than the advantages of appliance customization [7]. OTM acceleration appears to be clinically adopted to a very limited extent. Recently, 96% of members of the Australian Society of Orthodontists did not use any technique to accelerate OTM; only 3% used vibration, less than 1% used either piezocision or micro-osteoperforations, and none used PBM [8]. The orthodontist's dilemma centers around the question: What is the upper acceleration limit of the OTM? This is because of the well-known disadvantages of using heavy forces during 1970-1980 to accelerate OTM. Presently, evidence on canine retraction suggests that PBM induces faster tooth movements (from 0.31 to 1.22 mm/month) for a short and transient period, with limited, if any, influence on the overall treatment time (Table 1) [9-11].
- **Measure the accuracy of OTM.** We observed high heterogeneity in the methods of measuring OTM, that is by using a caliper or a digital caliper, and by: a) measurement on plaster casts, b) scanning measurement of conventional casts, c) measurement on digital scans of dental arches, d) measurement on occlusograms, e) measurement on radiography or CBCT image, f) measurement using different landmarks [9-16]. We think that standardized measurements by digital scans need to be developed to check PBM efficacy [11,15,16]. Nevertheless, contradictory evidence on scanner accuracy has been reported, and the measuring accuracy (7-9%) by digital scanning might not be enough in this field of research

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Table 1: Ergonomic issues in terms of appointments by different protocols of PBM during canine distalization

Procedure for canine distalization	Number of weeks for conventional fixed orthodontia	Laser procedure	Hypotized appointments for fixed orthodontia	Number of appointments for Laser treatments	Acceleration	Number for Laser appointments not concurrent with those of conventional fixed orthodontia
Impellizzeri et al. [9]	4	650+910 nm	1	4	0.68 mm/month	3
		2J/cm ²				
		500 mW				
Verella et al. [10]	8	940 nm	2	9	2.44 mm/8 weeks	7
		8J/cm ²			→	
		100 mW			1.22 mm/month	
Eid et al. [11]	12	980 nm	3	12	1.25 mm/12 weeks	8
		8J/cm ²	4	4	→	4
		100 mW			~0.31 mm/month	
		Protocol A				
		Protocol B				

[17,18]. In addition, CBCT could provide another chance [11,15,19]. Nevertheless, the repeated use of CBCT is restricted because of the exposure dose (about 80-84 Kv) and safety constraints implemented by European Basic Safety Standard requirements [20].

- Photo-absorption and PBM during the “orthodontic cell concert”.** The molecular mechanism of accelerated OTM has been reviewed elsewhere [21,22]. Concerning acceleration by PBM, improved data is required on the biological response, concerning specific metabolic and functional activities, on the orchestra of different cells (stem cells, osteoblasts, osteoclasts, immune cells, ligament fibroblasts, vascular cells, nervous cells), on the compression and tension site and during the orthodontic bone remodelling cycle [23]. Improved knowledge is important on the involved photoreceptors (mainly mitochondrial complex (cytochromes), and mechanosensitive channels (Piezo Channels 1) or heat-gated ion channels, water, cytoskeleton modification, lipids, and hydroxyapatite) [24,25]. The wavelength 1064 nm is known as the most suitable for its depth of optical penetration (~ 10 mm), while the diode laser (808 nm) has less penetration (5-6 mm). Nonetheless, the optical transport and energy loss in orthodontic bone tissues is unknown [26]. Thus, PBM efficacy should differ as bone thickness varies under the vestibular and palatal application points (from coronal to apical ones), and under distal and mesial application points during canine retraction. Nano Nd-Yag laser technology at 1064 nm seems to be promising as a way of delivering high energy flow in a very short time, without heating and increasing bone volume [27]. That said, photoreceptor

activation, involved at 1064 nm by Nd-Yag laser, must be identified more clearly as far as the time-dependent effects on osteoclasts and osteoblasts [27]. First of all, mitochondrial electron transport chains and adenosine triphosphate (ATP) production are influenced by different wavelengths [28]. 1064-nm light influences cytochrome complex I in addition to complexes III and IV, but complex II does not respond [28]. It has been reported that mitochondria and complex I are essential for osteoclast biogenesis and differentiation [29,30]. We would like to note that PBM is mainly applied at the compression site of canine distalization, where osteoclastogenesis is very important. Not less important to note that many conjectures have been reported around the influence of cytochromes on osteoblast function; clear evidence is lacking because osteoblast energetic metabolism is based mainly on aerobic glycolysis, and then with an unclear link with mitochondria and cytochromes [21]. Because of the complex molecular mechanisms during OTM, more studies on animal models, using multiplex imaging technology, gene expression microarray analysis on tissues, and salivomics are required.

- Informed consent for orthodontic treatment.** In the absence of a consensus on PBM efficacy via review and meta-analysis, the acquisition of valid consent is difficult, meaning a lack of effective communication around risk for shared decision-making and the provision of person-centered care [31]. In addition to those for fixed orthodontia, more frequent appointments might be required in the case of repeated PBM treatments. So, information about needing to take extra time off school or

work should be clearly indicated. At present, the influence of loss or delay of PBM appointments remains unknown.

- **Ergonomics in the orthodontic office.** We calculated the number of appointments vs benefits following three different protocols of PBM (Table 1) [9-11]. The treatment number with laser not concomitant with those of conventional fixed orthodontics is variable and not negligible. It is known that the cost increase is mainly due to laser instrumentation and its maintenance. The total number of appointments should be considered when calculating the patient's therapy cost. Treatments requiring a short time (around a total of a few minutes for PBM during canine distalization) are expected. Work time for PBM is expected to slightly increase the time of an orthodontic appointment, for example where arch wires are replaced and of course, cross-infection prevention is in place. However, even in the case of just a short appointment for PBM, the dental chair utilization, and then its costs, must take into account the time and costs for cross-infection prevention: these costs are hardly compressible during the COVID-19 pandemic.
- **Better and transparent reviewing process.** Undoubtedly, it is not easy "to cover" the many skills related to the interdisciplinary of a paper on PBM in orthodontia. The letter to the Editor by Priya et al. is an interesting example. It took into consideration many doubts and errors concerning the paper by Al-Shafi et al. [32,33]. Unfortunately, they were not taken into consideration by the reviewers, nor the readers did have any reply by Al-Shafi et al. Furthermore, exaggerated claims in SR abstracts are very frequent [1].
- **Exaggerated claims on the social media platform.** In general, there is insufficient information on the internet regarding accelerated orthodontics [34]. Orthodontists should be aware of the exaggerated claims on some websites and social media platforms compared to sound scientific evidence [35]. The further example is indicative. According to Meme's evidence, orthodontic treatment is reduced by 35% (median 160 days vs 245 days respectively in the PBM group vs control group) compared to 80% as presented on the producer website [36,37].

We believe it is important to address these relevant issues for the future affirmation of PBM therapy as a promising adjuvant therapy in orthodontics.

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