OrthoPulse®
Light Accelerated Orthodontics

The Science Behind Light Accelerated Orthodontics™

Dr. Peter Brawn
AAO 2016 - Orlando, Florida

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DR. PETER BRAWN

Dr. Peter Brawn is Chief Scientific Officer and a founder of Biolux Research, a world leader in the development of innovative Light Accelerated Orthodontics™ technology and products for use in orthodontics, implantology, and other dentistry markets. Dr. Brawn pioneered the use of safe, gentle OrthoPulse™ light therapy in dentistry and orthodontics. He is an inventor with over 20 patents and patents pending.

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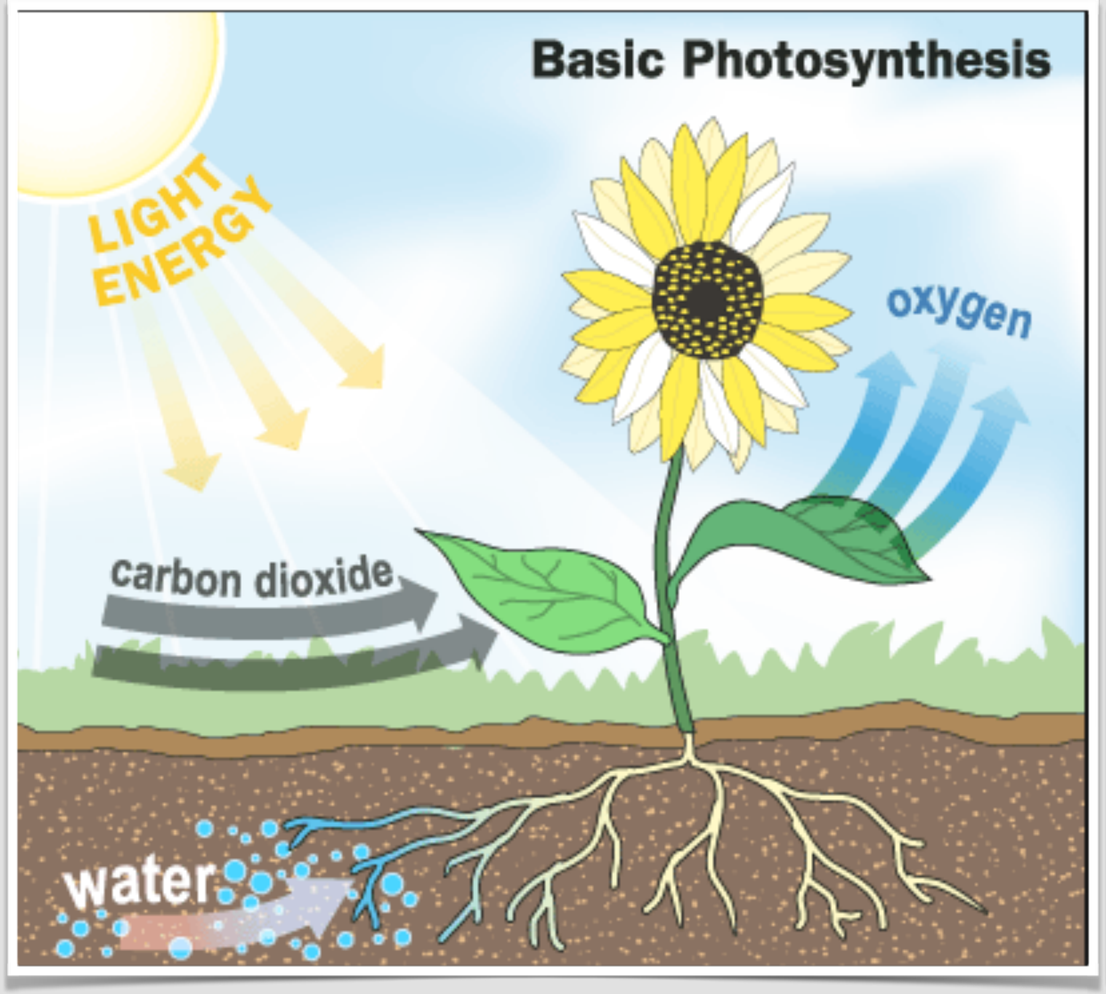
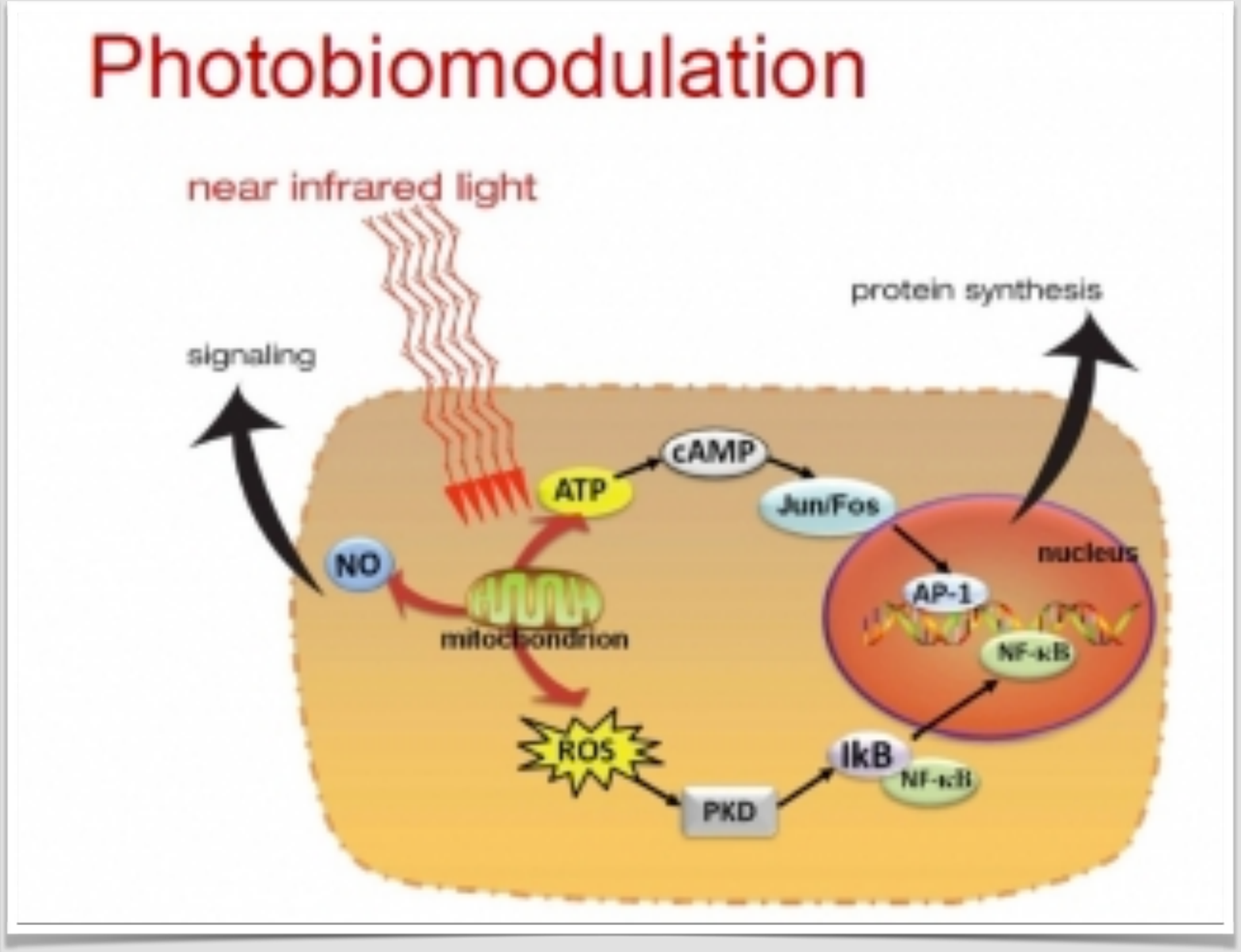
1 PHOTOBIOMODULATION





Conversion of light energy into chemical energy

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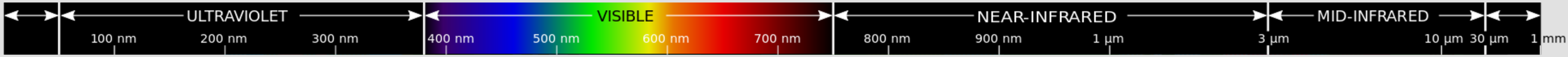
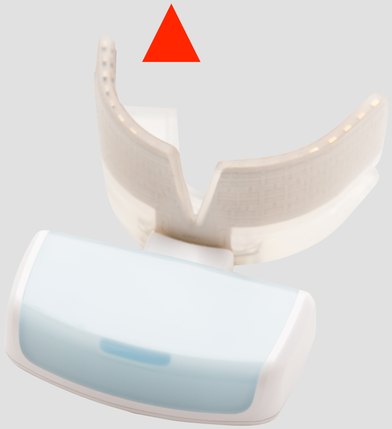
PHOTOBIOMODULATION
THERAPEUTIC APPLICATION OF RED AND NEAR INFRARED PHOTONS

"Light in the red to near infrared **(NIR) range (600–1000 nm)** generated by using low energy laser or light-emitting diode (LED) arrays has been reported to have **beneficial biological effects** in many injury models. Such photobiomodulation has been observed to **increase mitochondrial metabolism**, facilitate wound healing and **promote angiogenesis in skin, bone, nerve** and skeletal muscle."
- Zhang R et al, 2009



US National Library of Medicine
National Institutes of Health
pubmed.gov lists more than 5000 peer-reviewed published articles on photobiomodulation or low-level light (laser) therapy (LLLT)



OrthoPulse®
(850nm)

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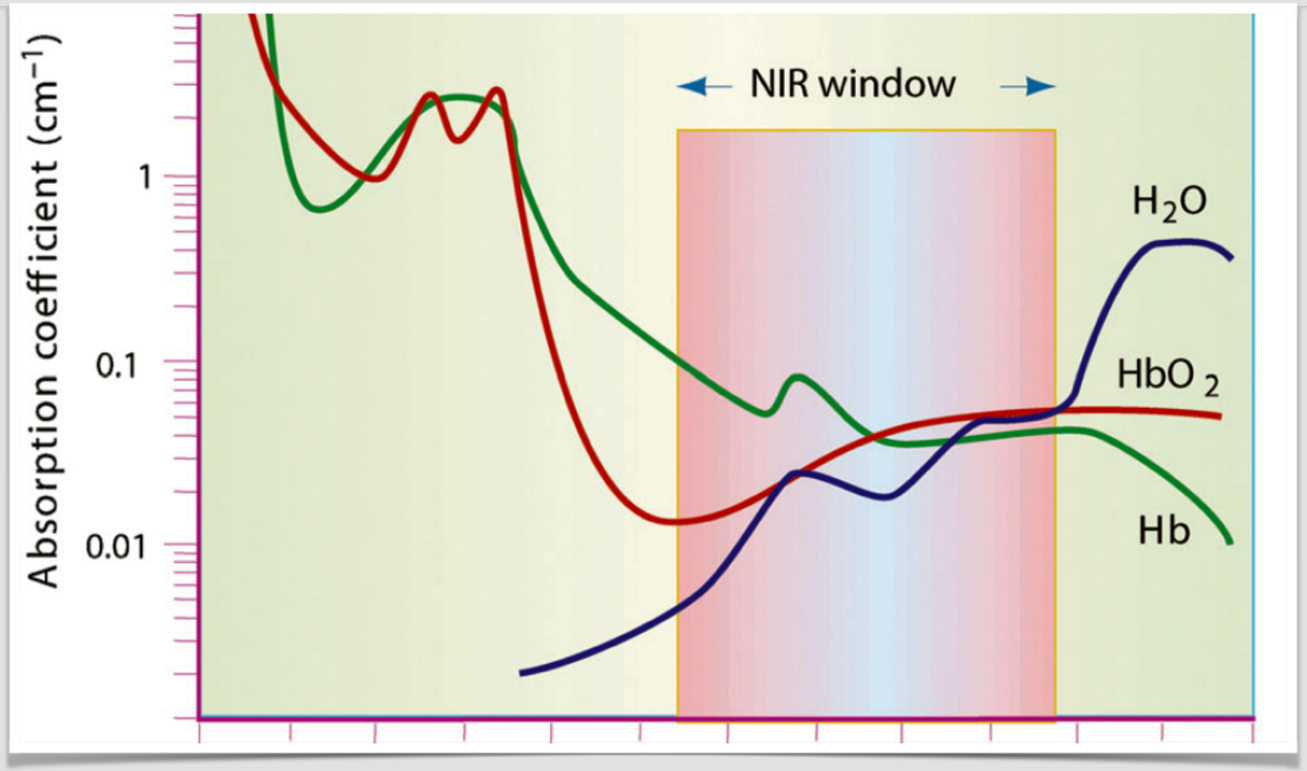
OPTICAL WINDOW



There exists an “Optical Window” between 600 – 1200nm in biologic tissues. This allows for maximum tissue penetration of photons.

Hamblin MR, Waynant RW, Anders J. Mechanisms for Low-Light Therapy, Proc. of SPIE Vol. 6140, 614001, (2006)

Ex-vivo biopsy tissue study shows higher wavelengths penetrate tissue deeper, Stolik *et al.* ‘Ex-vivo’ biopsy tissue study evaluated tissue penetration depths of 632, 675, 780 and 835 nm light measurement of the penetration depths of red and near infrared light in human “ex vivo” tissues.

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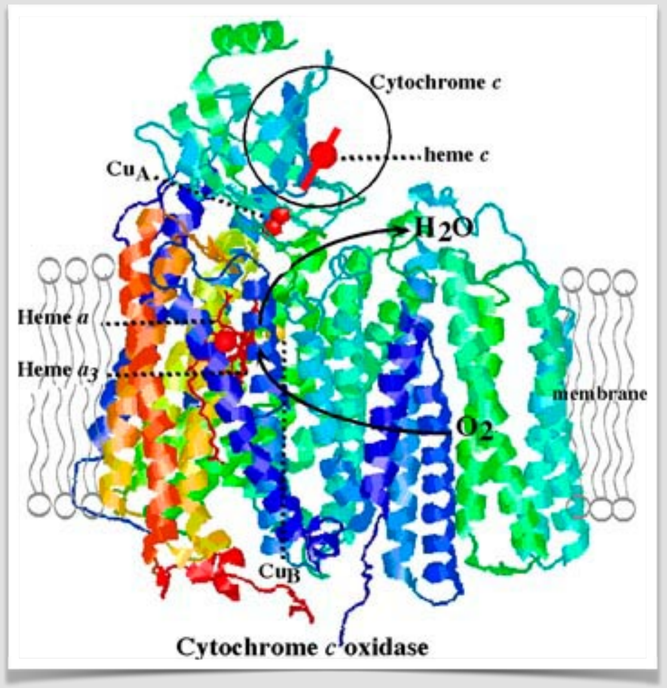
PHOTOBIOMODULATION MECHANISMS OF ACTION

1931 Nobel Prize
Winner in Physiology:
Otto Warburg



- Otto Warburg discovered Cytochrome c Oxidase (CCO), the terminal enzyme in the mitochondrial oxidative respiration chain

- He demonstrated that the mitochondrial CCO was responsive to light stimulation

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2 HISTORY

- In 1967 Prof. Endre Mester – “the Father of Photobiomodulation” - of Semmelweis University in Budapest wanted to test if laser radiation could cause cancer in mice[1]
- He shaved the dorsal hair, divided them into two groups and gave a laser treatment with a low powered ruby laser (694 nm) to one group.
- They did not get cancer, and to his surprise the hair on the treated group grew back more quickly than the untreated group. This demonstrated that the mitochondrial CCO was responsive to light stimulation …
- … and gave birth to the field of photobiomodulation. Since then more than 4,000 studies of LLLT have been published.

2. E. Mester, B. Szende and P. Gartner, The effect of laser beams on the growth of hair in mice, Radiobiol Radiother (Berl) 9 (1968) 621-6.

Source: Mechanics of Low Level Laser Therapy – Michael R. Hamblin, Department of Dermatology, Harvard Medical School

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KNOWN PHOTOBIOMODULATION MECHANISMS

1. Increases mitochondrial chromophores (inc. Cytochrome C Oxidase) absorption of photons, proton pumping and ATP production

   → Increased energy available to the cell -> *increased / normalized metabolism*

2. Increases Reactive Oxygen Species (ROS) production and mitochondrial signalling

   → Stimulates/suppresses transcription factors, DNA/RNA synthesis -> *plethora of tissue/cellular activity*

3. Induces Nitric Oxide (NO) production through absorption of photons by Nitric Oxide Synthase

   → Increased micro and regional blood flow and osteoclastic activity

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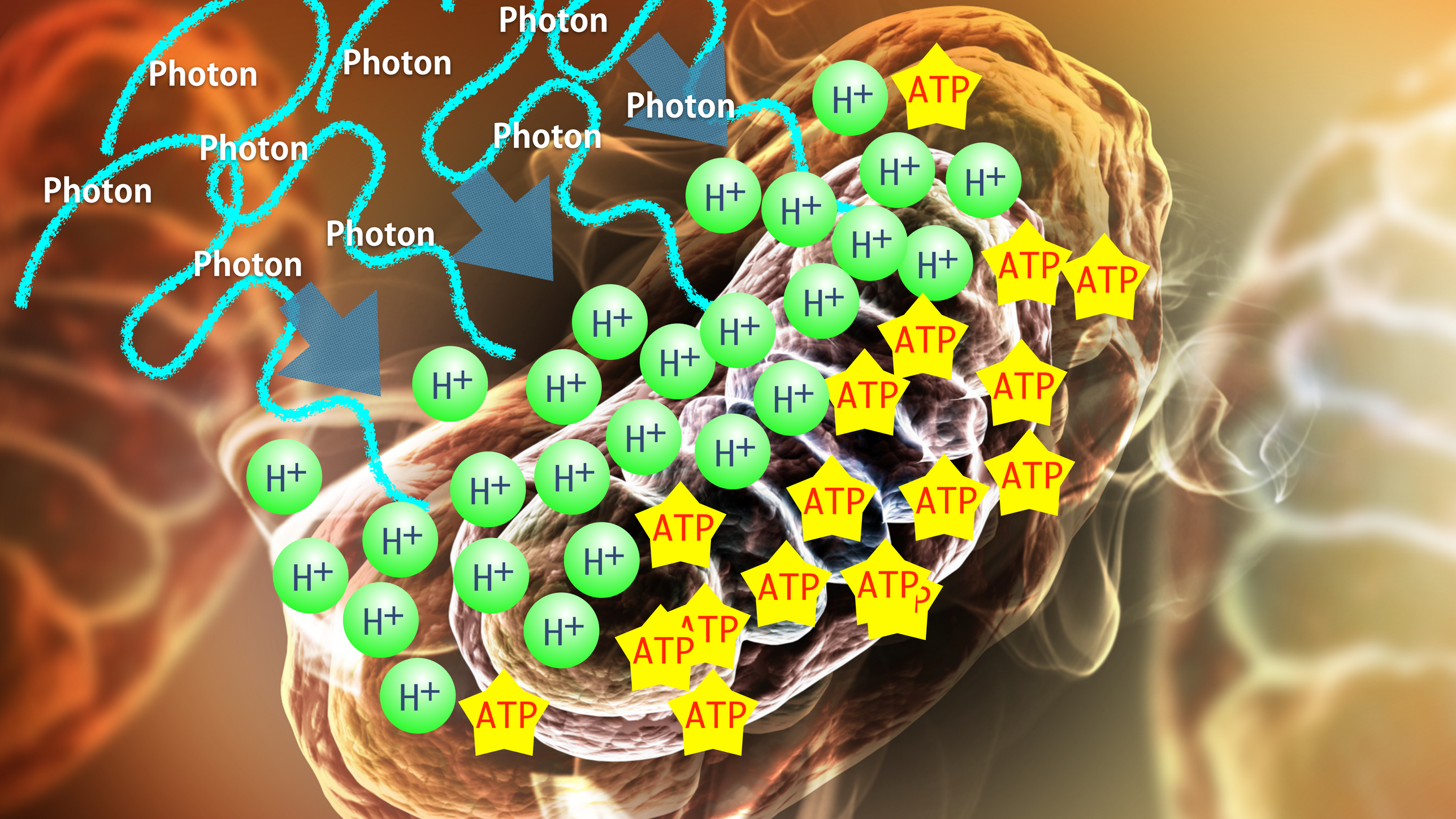
Photon
Photon
Photon
Photon
Photon
Photon
Photon
Photon
H+
ATP

1 PHOTOBIOMODULATION MECHANISMS OF ACTION

- Human neuronal progenitor cells were grown in tissue culture and were treated by Ga-As laser (808 nm, 50 mW/cm2, 0.05 J/cm2), and ATP was determined at 10 min after laser application

- **2-fold increase in ATP production with one Photobiomodulation treatment**

U. Oron, S. Ilic, L. De Taboada, and J. Streeter. Photomedicine and Laser Surgery. June 2007, 25(3): 180-182. doi:10.1089/pho.2007.2064

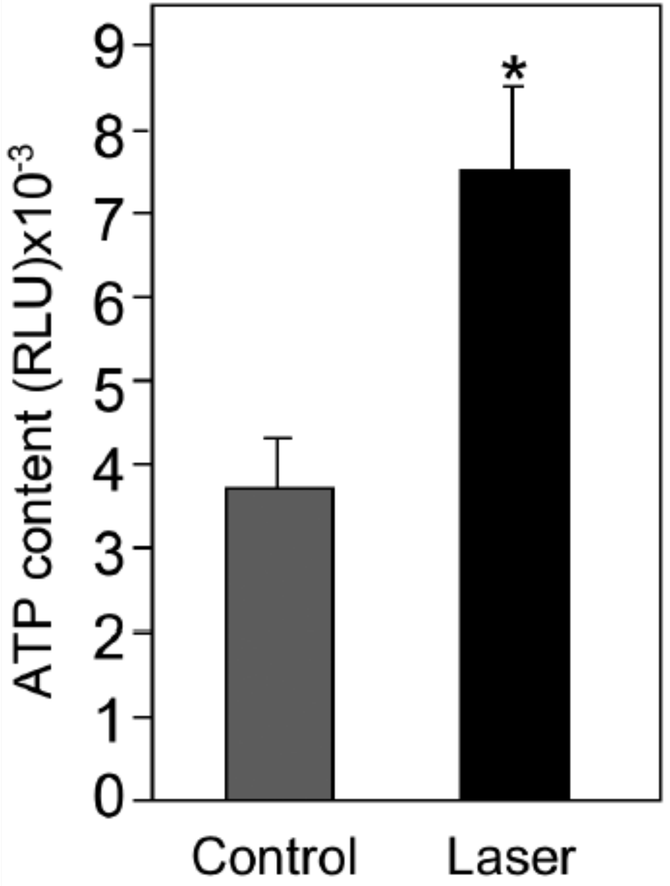

FIG. 1. Adenosine triphosphate (ATP) content in control non-laser-irradiated (dashed column) and laser-irradiated (solid column) human neuronal progenitor cells. Results are expressed as mean ± standard error of the mean (SEM). *$p < 0.05$. RLU, relative luminescent unit.

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PBM LEADS TO…

↑ Proliferation and differentiation of osteoblast

↑ Activity of osteoblasts

↑ Bone formation

Cossetin E, Janson G, de Carvalho MG, de Carvalho RA, Henriques JF, Garib D. Influence of low-level laser on bone remodeling during induced tooth movement in rats. Angle Orthod. 2013 Nov;83(6):1015-21.

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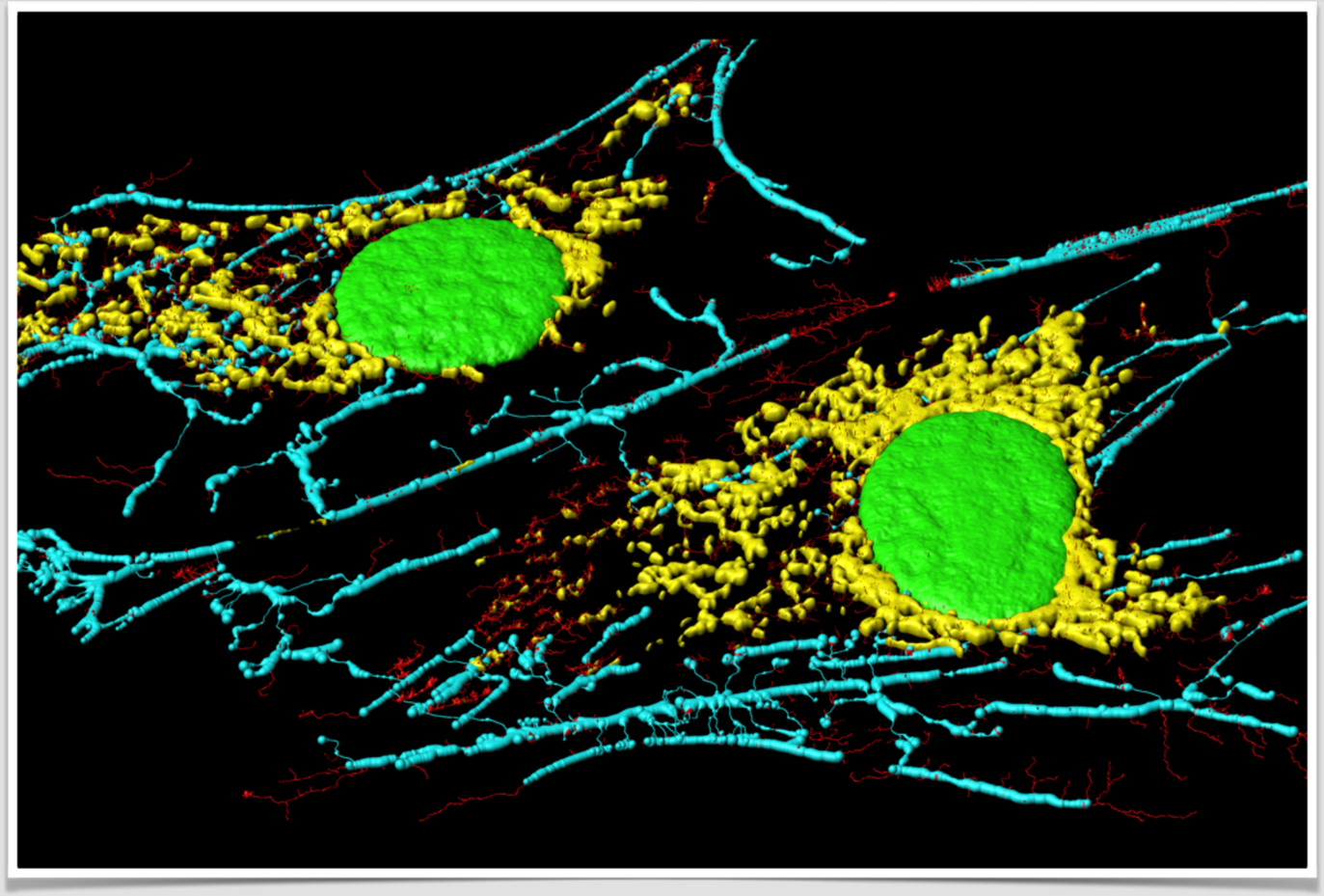
PBM LEADS TO…

↑ Procollagen synthesis

↑ Collagen metabolism

↑ Proliferation rate of fibroblasts

↑ Activity of fibroblasts



De Oliveira RF, Oliveira DA, Monteiro W, Zangaro RA, Magini M, Soares CP. Comparison between the effect of low-level laser therapy and low-intensity pulsed ultrasonic irradiation in vitro. Photomed Laser Surg. 2008 Feb;26(1):6-9.

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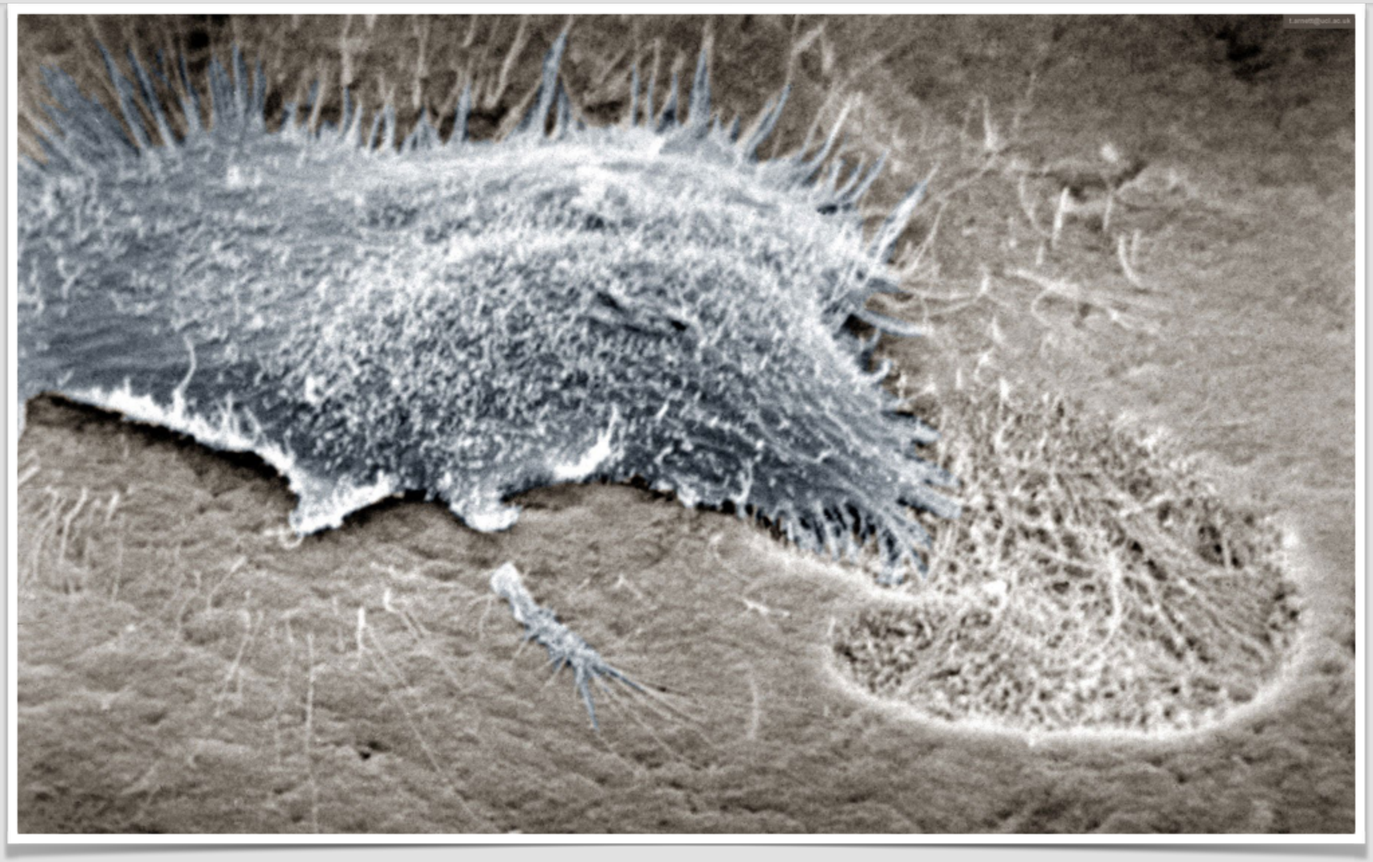
PBM LEADS TO…

↑ Stimulate formation of osteoclast-like cells via RANK expression

↑ Osteoclastic activity is facilitated by the RANK/RANKL system

↑ Proliferation & Differentiation of Osteoclast



Sohn H1 Ko Y, Park M, Kim D, Moon YL, Jeong YJ, Lee H, Moon Y, Jeong BC, Kim O, Lim W1. Effects of light-emitting diode irradiation on RANKL-induced osteoclastogenesis. Lasers Surg Med. 2015 Nov;47(9):745-55.

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PHOTOBIOMODULATION - PRACTICAL APPLICATIONS

Field of application	Treatment	Devices
Dentistry	Pain, hypersensitivity of the teeth, problems with the jaw joints, stability of implants, oral muscositis, acceleration of tooth movement	• THOR • DentaRay™ • Dental.M • MedX Oralase • iLase™ • OsseoPulse™ • OrthoPulse™
Medicine	Wound healing, inflammation, arthritis, hair loss, neurorehabilitation	• THOR • GentleWaves® • WARP 10® • iGrow® • HairMax Lasercomb®
Chiropractic	Pain, musculoskeletal troubles	• Theralase® • Tanda Professional Restore • MedX Phototherapy
Ophtalmology	Macular degeneration due to aging	• Lumithera
Dermatology	Anti-aging	• RJ Laser • Truth Vitality Lux Renew

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PHOTOBIOMODULATION AND ORTHODONTICS

ORTHODONTICS IN ANIMAL MODELS (54+ ARTICLES)

- Kawasaki and Shimizu, 2000 concluded that the low energy laser irradiation can **accelerate tooth movement** accompanied with alveolar bone remodelling in the rat model.
- The same effects were observed when the LLL therapy was applied to the rabbit model. Zhu et al, 2001
- Fujita et al, 2008 demonstrated that laser irradiation **stimulates the velocity of tooth movemen**t via induction of RANK and RANKL in rats.
- **Increased expression of fibronectin and Type I collagen** in LLL tooth movement in rats. Kim et al, 2008
- LLLT **accelerates the velocity of tooth movement** via stimulation of the alveolar bone remodelling in rats. Yoshida et al, 2009
- LLLT **facilitates the velocity of tooth movement** and MMP-9, cathepsin K, and integrin subunits of alpha(v)beta3 expression in rats. Yamaguchi at al, 2010

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POSITIVE EFFECTS OF PHOTOBIOMODULATION WITH LASERS (LLLT)

HUMAN ORTHODONTIC TOOTH MOVEMENT

- Increased velocity (**by 2.0 fold**) of canine movement (N=15) and decreased pain in lased group (809nm). 0,3,7,14 day exposure monthly. Youssef et al. (2008).

- Significantly higher acceleration (**by 1.3 fold**) of the retraction of treated (780nm) canines (N=11). 0,3,7,14 exposure monthly. Cruz et al. (2004).

- Laser irradiated canines moved significantly faster (**by 1.9 fold**) than that of the non-irradiated group ($p<0.05$). Sousa et al. (2011).

- An average increase (**by 30%**) in the rate of tooth movement found for the low-intensity laser therapy group ($p<0.05$). Mehta & Patil (2012).

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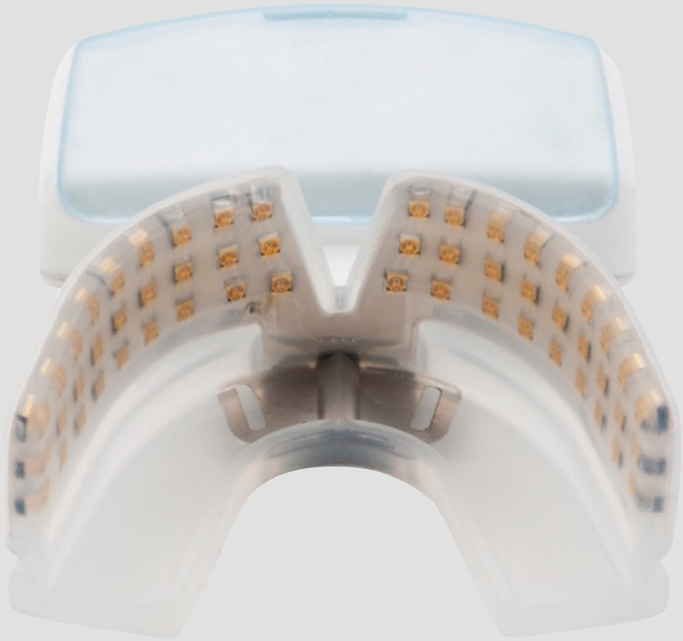
ORTHOPULSE®

LIGHT ACCELERATED ORTHODONTICS



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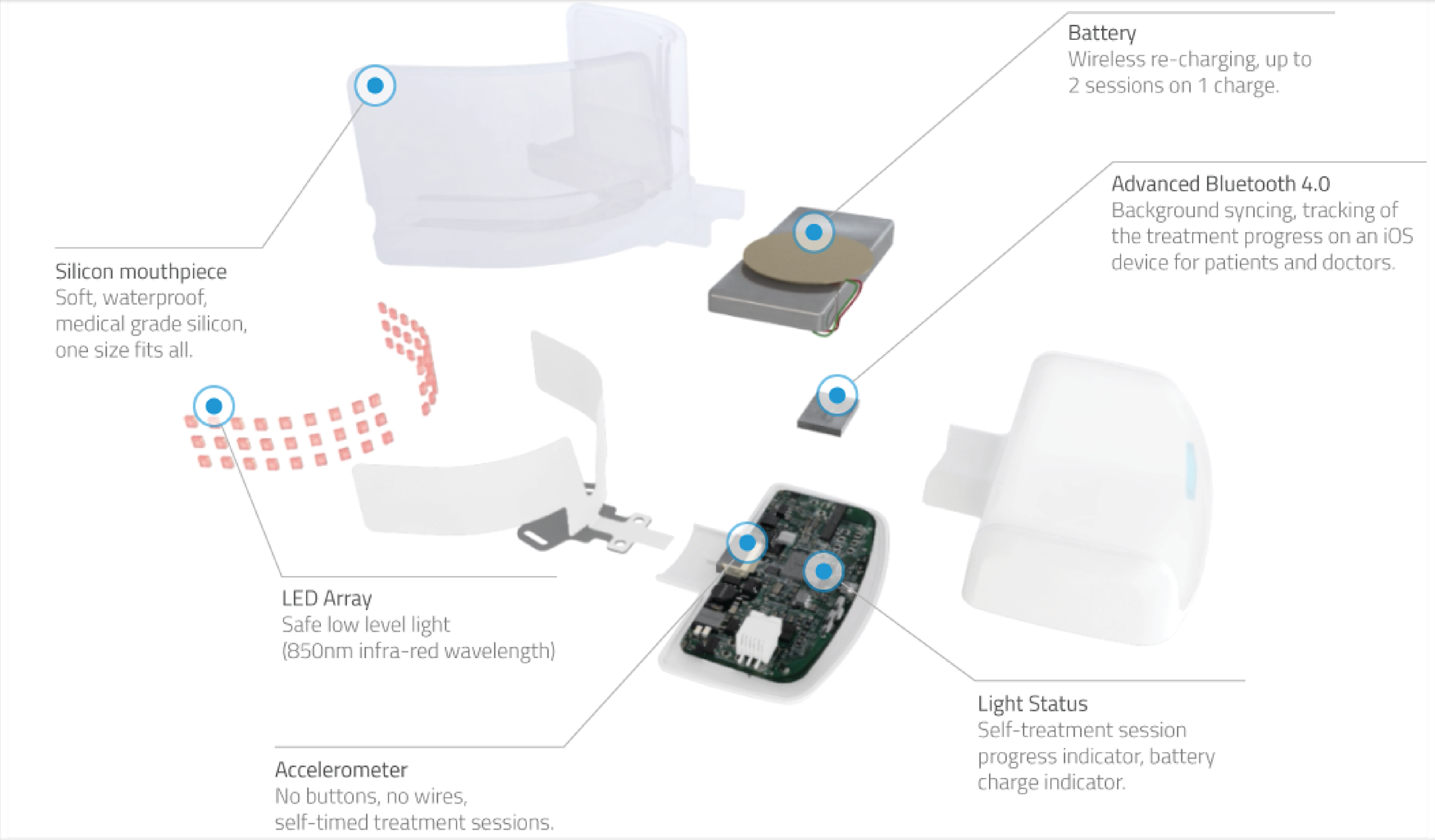
ORTHOPULSE®



Battery
Wireless re-charging, up to 2 sessions on 1 charge.

Advanced Bluetooth 4.0
Background syncing, tracking of the treatment progress on an iOS device for patients and doctors.

Silicon mouthpiece
Soft, waterproof, medical grade silicon, one size fits all.

LED Array
Safe low level light (850nm infra-red wavelength)

Accelerometer
No buttons, no wires, self-timed treatment sessions.

Light Status
Self-treatment session progress indicator, battery charge indicator.

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ORTHOPULSE® CLINICAL STUDIES AND TRIALS

Forsyth
Pioneering Discoveries
Profound Change
Harvard School of Dental Medicine Affiliate

UAB
THE UNIVERSITY OF
ALABAMA AT BIRMINGHAM

USC University of Southern California

MAHIDOL UNIVERSITY

Kyung Hee University

THE UNIVERSITY OF SYDNEY

Tufts UNIVERSITY

Universität zu Köln

- Claims of accelerated orthodontic tooth movement and reduction of treatment times require exceptional scientific and clinical evidence.
- Since 2003, there have been over 30 OrthoPulse® published clinical trials, *in vivo* and *in vitro* studies.
- More than 12 Biolux Research studies have been published in the scientific literature.
- More than 400 patients have been treated in clinical trials world-wide.

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ORTHOPULSE® *in vitro* EVIDENCE

- Stimulation of gene expression in human cells[1]
- Increased proliferation of gingival fibroblasts and endothelial cells[2]
- Stimulated proliferation and mineralization of human osteoblasts[3]
- Modulates PDL cell response, which could regulate bone turnover during orthodontic tooth movement[4]

1 Yen et al. Visible red and infrared light stimulates differential gene expression in human MSF cells. Orthod Craniofac Res. 2015 Apr;18 Suppl 1:50-61

2 Iscan et al. Photobiostimulation of gingival fibroblast and vascular endothelial cell proliferation. Presented in Annual Meeting of Turkish Society of Orthodontics, October 26-30, 2014 Ankara, Turkey.

3 Le et al. Human osteoblast response to LED photobiomodulation. Presented at IADR 2015 General Session. Boston, MA. March 14, 2015.

4 Konerman et al. Impact of LED photobiomodulation on the gene expression profile of PDL cells under simulated inflammation. In review.

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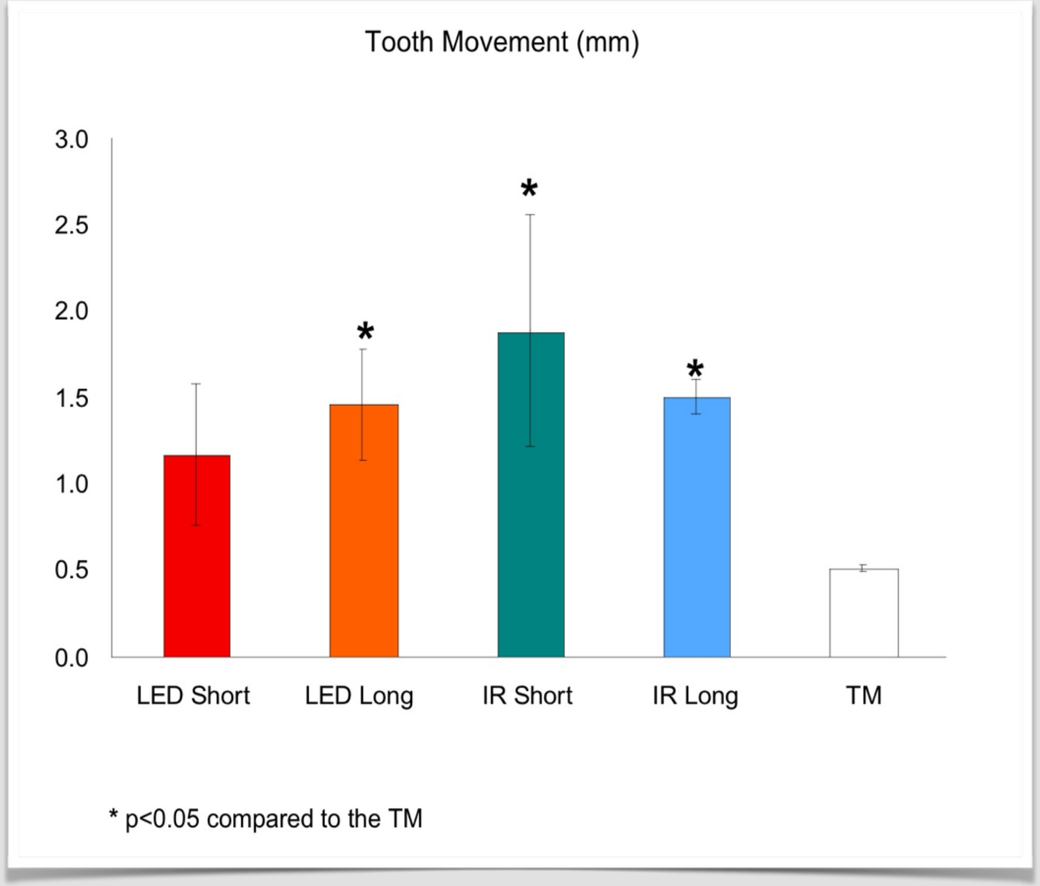
ORTHOPULSE® *in vivo* EVIDENCE



36 healthy CRL-CD male rats:

- 5 groups of 6 rats (experimental)
- 1 group of 6 rats (baseline)

Photobiomodulation-induced tooth movement using extra-oral transcutaneous phototherapy utilizing Red LED (625nm) radiation versus nIR-Laser (855nm) radiation on the rat periodontium and on orthodontic tooth movement

Susanne Chiari, Susan S. Baloul, Emilie Goguet-Surmenian, Thomas E. Van Dyke, Alpdogan Kantarci

In Review

Light treated animals showed an average 3.3-fold increase in tooth movement compared to control

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ORTHOPULSE® *in vivo* EVIDENCE

- An average 3.3-fold faster rate of tooth movement[1]
- 80% less root resorption in animals treated with 620 nm light[2]
- Significantly more mature bone in expanded sutures[3]
- Significantly lower failure rate of immediately loaded TADs[4]

1 Chiari S et al. Photobiomodulation-induced tooth movement using extra-oral transcutaneous phototherapy on the rat periodontium. In review.

2 Ekizer A et al. Effect of LED-mediated photobiomodulation therapy on orthodontic tooth movement and root resorption in rats. Laser Med Sci., 2012 Aug 29.

3 Ekizer A et al. Light-emitting diode photobiomodulation: effect on bone formation in orthopedically expanded suture in rats-early bone changes. Laser Med Sci., 2012 Nov 9.

4 Uysal T et al. Resonance frequency analysis of orthodontic mini-screws subjected to light-emitting diode photobiomodulation therapy. Eur J Orthod., 2012 Feb; 34(1):44-51.

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ORTHOPULSE® CLINICAL EVIDENCE

FIXED APPLIANCES

- No clinically significant root resorption[1,2]
- 46% increase in rate of space closure in adults compared to control[2]
- 54% reduction in time to achieve anterior alignment compared to controls[3]

1 *Nimeri et al. The effect of photobiomodulation on root resorption during orthodontic treatment. Clin Cosmet Investig Dent 6:1-8.*

2 *Samara et al. Velocity of en-masse space closure with and without Photobiomodulation: a prospective RCT. In review.*

3 *Shaughnessy et al. Intraoral photobiomodulation-induced orthodontic tooth alignment: a preliminary study. BMC Oral Health, 16:3. 2016*

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ORTHOPULSE® CLINICAL EVIDENCE

FIXED APPLIANCES

Intraoral photobiomodulation-induced orthodontic tooth alignment: a preliminary study

Timothy Shaughnessy, Alpdogan Kantarci, Chung How Kau, Darya Skrenes, Sanjar Skrenes and Dennis Ma

BMC Oral Health 2016;16:3. doi: 10.1186/s12903-015-0159-7. Epub 16 Jan 2016.

OrthoPulse® PBM increased the average rate of tooth movement by 2.9-fold, resulting in a 54 % average decrease in alignment duration versus control.

BMC
Oral Health

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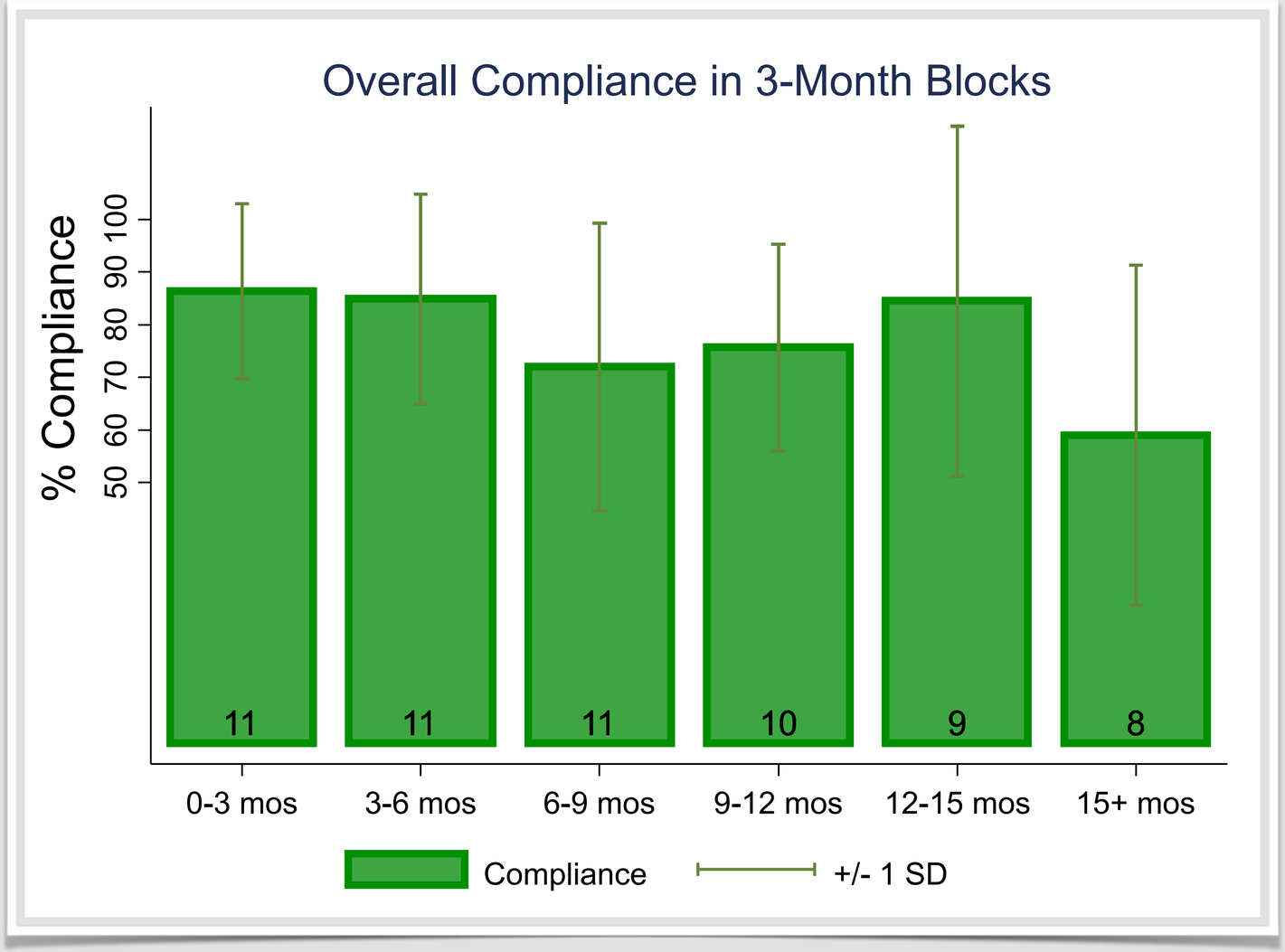
ORTHOPULSE® CLINICAL EVIDENCE

FIXED APPLIANCES



PATIENT COMPLIANCE IN 3-MONTH INCREMENT

- Average compliance demonstrated 86% over 6 months and 82% over one year.
- OrthoPulse™ has high compliance by patients.

(Shaughnessy et al., 2016)

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ORTHOPULSE® CLINICAL EVIDENCE

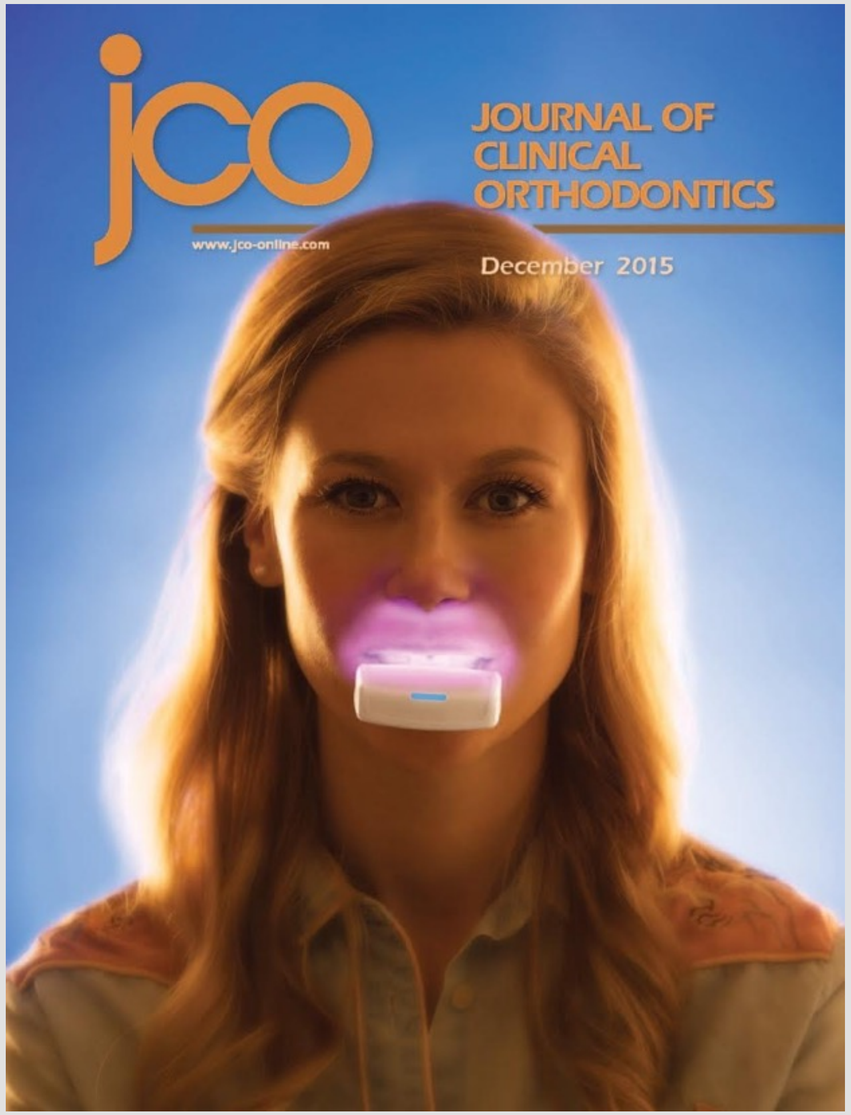
FIXED APPLIANCES

Long Distance Orthodontic Treatment With Adjunctive Light Therapy

Timothy G. Shaughnessy DDS, MS

J Clin Orthod. 2015, Dec;49(12):757-69

Two long-distance patients, unable to attend frequent and regular appointments, achieved excellent results at a reduced overall treatment time when using OrthoPulse®



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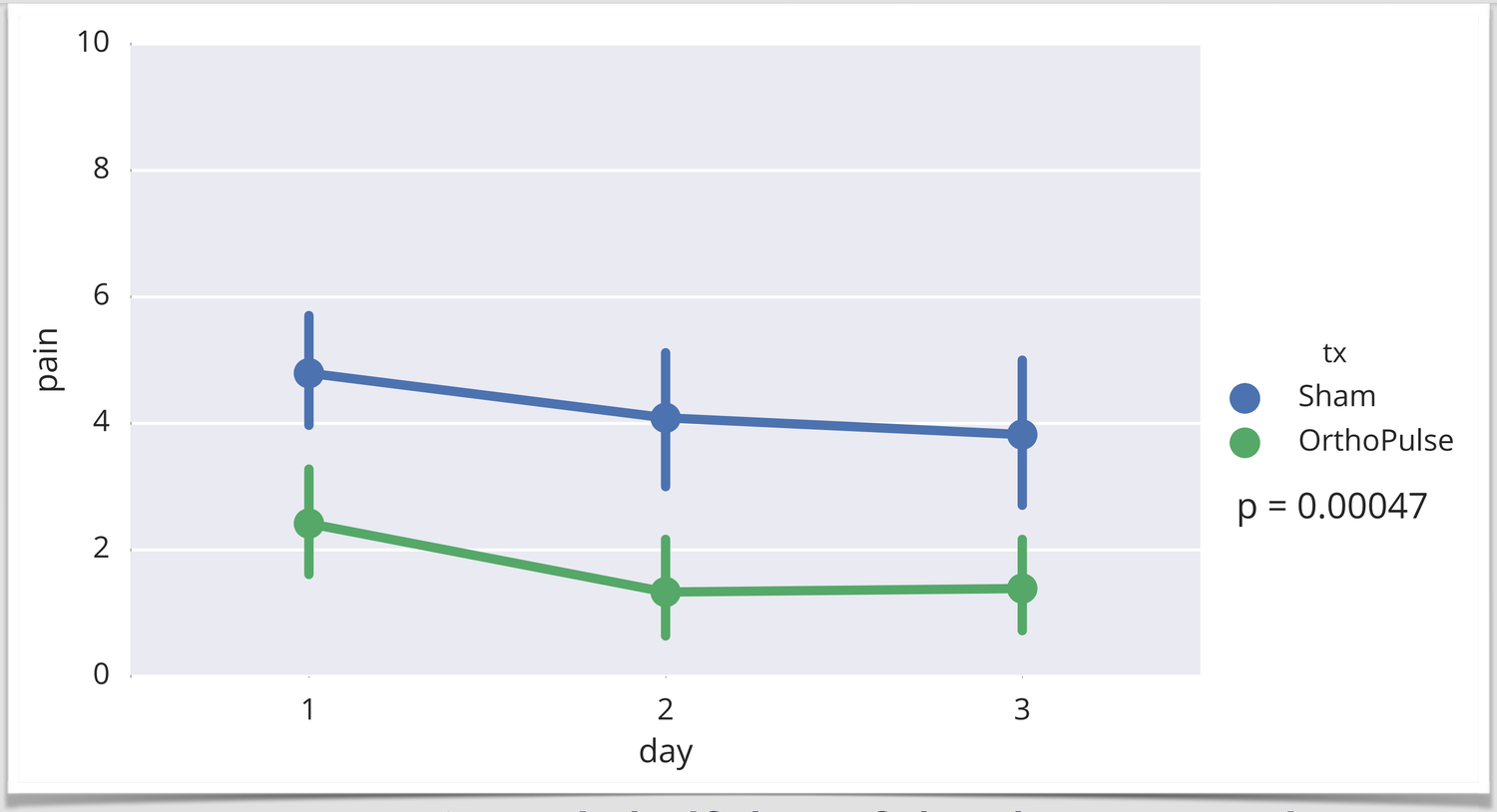
ORTHOPULSE® CLINICAL EVIDENCE

ORTHODONTIC PAIN

RCT: Pain perception between sham-control and PBM treated patients undergoing orthodontic treatment with fixed appliances

Nour Al-Okla, Dana Bader, Anas Al-Mulla, Donald Ferguson
European University College, Dubai, UAE
Department of Orthodontics

To be submitted



Pain perceived by the OrthoPulse® group was approximately half that of the sham-control group than in Sham-control (*p* < 0.001, Figure 1).

Pain rating was on average 4.24 and 1.71 for the sham and OrthoPulse® groups, respectively. The biggest difference was on Day 2, when Sham rated pain 3.1-fold higher than OrthoPulse® (mean of 4.09 vs 1.33).

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ORTHOPULSE® CLINICAL EVIDENCE

ALIGNERS

- 63% reduction in the average time per aligner during OrthoPulse® treatment as compared to the conventionally recommend aligner wear time[1]

- No measurable root resorption in 6 months[1]

1 Dickerson, T. A randomized controlled crossover trial on the effect of OrthoPulse® photobiomodulation on the rate of aligner progression during alignment with Invisalign® aligners. To be submitted for publication.

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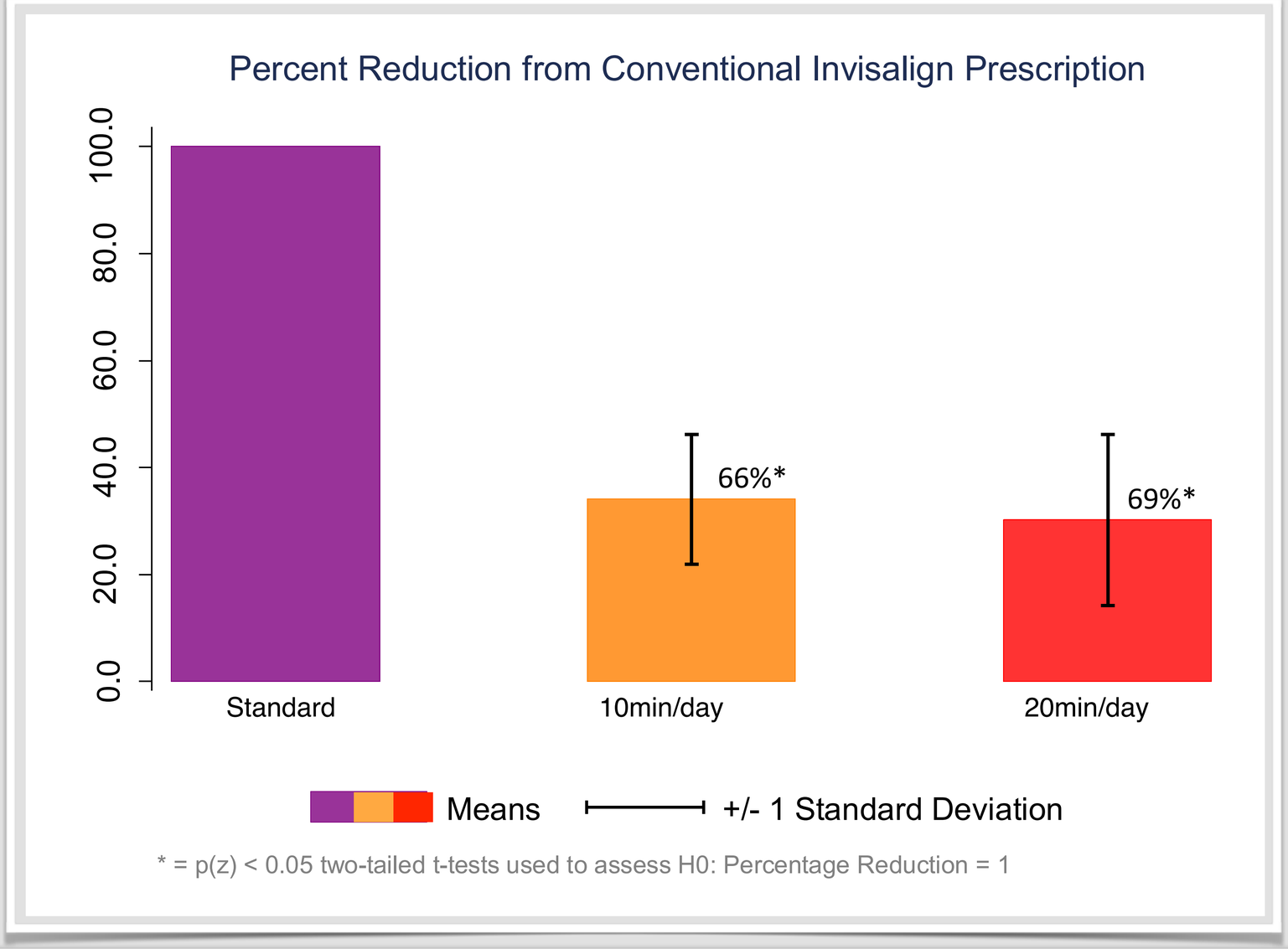
PILOT: OPTIMIZING INVISALIGN® AND ORTHOPULSE® TREATMENT

PI: TODD DICKERSON, PHOENIX, AZ

- Aligner switching time (in days) reduced by 2/3
- 2 treatments per day does not make a significant difference in the results.



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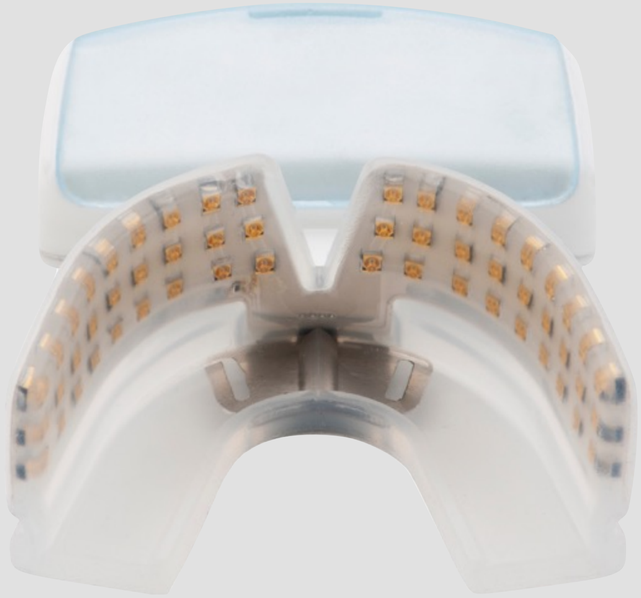
LIGHT ACCELERATED ORTHODONTICS™ CLINICAL ADVANTAGES

1. Photobiomodulation increases energy production (ATP) in stressed cells and tissue.
2. Photobiomodulation accelerates bone and soft tissue remodelling process.
3. Non-specific: ALL cells and tissues benefit
4. Works with any orthodontic system - technique independent



5. No change in Doctor's preferences or clinical techniques
6. There may be optimization through the use of modified mechanics and protocols
7. Non-invasive, drug-free and extremely low risk profile (Class II device)
8. Scientifically proven effect and mechanisms understood

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For up-to-date comprehensive information, please download the ***OrthoPulse Clinical and Scientific Dossier*** at orthopulse.com

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QUESTIONS & ANSWERS

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