The AAO is the only organization solely dedicated to orthodontic specialists. Membership leaders work to develop tools and support needed to succeed in practice.

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**Bio introduction**

Eiji Tanaka
Professor and Chair, Department of Orthodontics and Dentofacial Orthopedics
Institute of Health Biosciences
The University of Tokushima Graduate School

Graduated from Osaka University Faculty of Dentistry in 1988 and went on to complete his PhD in 1993.

Gained the special license as an orthodontist, the orthodontic instructor license, and an accredited specialist in temporomandibular disorders.

Took up his current post in 2008 and in May 2015 has also been a Distinguished Adjunct Professor at King Abdulaziz University, Jeddah, Saudi Arabia.

My research is centered around biomechanics of the temporomandibular joint (TMJ), application of low-intensity pulsed ultrasound in dental tissue engineering, and development of nucleic acid medicine for treatment of muscle atrophic diseases.

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**Introduction of accelerated orthodontic tooth movement by a low-intensity pulsed ultrasound exposure**

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**Local responses of periodontal tissues to mechanical loading during orthodontic tooth movements**

A case of orthodontic treatment using a lingual bracket system

Average duration for orthodontic treatment: about 2-3 years

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**Root resorption**

Before treatment

After treatment

The fact is that orthodontic tooth movement directly causes an irreversible resorption of the root. Due to orthodontic tooth movement, the most severely resorbed teeth are maxillary central and lateral incisors, followed by the second premolars.

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**Histological Aspect of Root Resorption**

Application of adequate mechanical stimulation to bone is essential for maintaining bone mass and strength. Mechanical stimuli have been reported to activate both osteoblasts and osteoclasts, resulting in the promotion of bone remodeling. During orthodontic treatment, root resorption sometimes occurs because odontoclast is similar to osteoclast.

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**Histological Aspect of Root Resorption**

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Osteoblasts not only play a central role in bone formation by synthesizing multiple bone matrix proteins, but also regulate osteoclast maturation by soluble factors and cognate interaction resulting in bone resorption. Osteoclast maturation requires stimulation by receptor activator of nuclear factor κB ligand (RANKL) expressed on osteoblasts. Cementoblasts share many properties with osteoblasts and recently, it has been reported that cementoblasts also express RANKL and osteoprotegerin (OPG) and probably influence cementoblastogenesis process.

Interventions on accelerating orthodontic tooth movement

- **Surgical procedure**
  - Corticotomy: Making small perforations on the alveolar bones
  - Dentoalveolar distraction: Making monocortical perforations on alveolar bones around canines
  - Periodontal distraction: Making vertical grooves on the mesial side of the first premolar extraction sockets

- **Non-surgical procedure**
  - Low-level laser therapy
  - Electrical current
  - Pulsed electromagnetic field
  - Mechanical vibration
  - Low-intensity pulsed ultrasound

Efficacy of interventions on accelerating orthodontic tooth movement: A systematic review

Inclusion criteria for included studies:
- Randomized or quasi-randomized controlled trials up to 2014
- Effects of interventions:
  - Corticotomy is safe and able to accelerate orthodontic tooth movement.
  - Dentoalveolar or periodontal distraction is promising in accelerating orthodontic tooth movement but lacks convincing evidence.
  - Low-level laser therapy is safe but unable to accelerate orthodontic tooth movement.
  - Electronic current and pulsed electromagnetic fields do not allow for solid conclusions in accelerating orthodontic tooth movement.

Today’s lecture objectives

1) to recognize the effectiveness of LIPUS on orthodontic tooth movement,
2) to apply the LIPUS in clinical orthodontic treatment.

Ultrasound

- Ultrasound (US) is an acoustic radiation at frequencies above the limit of human hearing (30Hz – 20 kHz).

  **Various uses of US**
  - For informative:
    - Sonar
    - Non-invasive diagnosis device
  - For mechanical:
    - US washer
    - US metal welder
    - US humidifier
    - US beauty device (Esthetic aim)

A fund of knowledge about the history of US development

1912 An excellent passenger ship, Titanic (UK), struck against an iceberg.
1919 France developed a Sonar (sound navigation ranging) with an ultrasound oscillator in order to protect from Germany submarine during the first World war.

US Medical Uses

It has previously been shown that US can accelerate many kinds of bone healing, and stimulate nonunion and delayed union (Dickson et al., 1994). In clinical practice of orthopedic surgery, therapeutic US is widely used to decrease joint stiffness, reduced pain and muscle spasms, improve muscle mobility, and accelerate bone healing. Low-intensity pulsed US (LIPUS) is commonly used as a promoter and accelerator of bone fracture healing.

Note:
- On April 2002 immediately before FIFA World Cup, Beckham was injured during a Champions League match, breaking the second metatarsal bone in his left foot. Most people gave up his play in the World Cup games. However, treatment remedy with LIPUS and electrostimulation enabled him to play soccer in the game because these treatments accelerated a bone healing in fracture site.
In vivo experiment

Materials and Methods

12 week-old Wistar strain male rats (n = 8)

- Force application on 1st molar
  - Frequency: 1 MHz
  - Intensity: 30 mW/cm²
  - Pulsed: 1:4 (2 ms on and 8 ms off)
  - Duration: 15 minutes per day

Micro-CT observations

Control | LIPUS
---|---

Inubushi T, Tanaka E, et al., 2013 in Bone

Histometric findings

Control | LIPUS
---|---

Inubushi T, Tanaka E, et al., 2013 in Bone

US Dental Uses

Recently, a great concern has increasingly been given to US therapy aimed for dental treatment.

- LIPUS accelerates bone formation at the osteodistraction site.
  - El-Bialy et al., 2008 in J Dent Res

- LIPUS stimulation enhances the healing process of orthodontically-induced root resorption in humans.
  - El-Bialy et al., 2002 in Ann Biomed Eng

- Little is known about LIPUS effects on the acceleration of tooth movement and the prevention from orthodontically-induced root resorption.

LIPUS accelerates bone formation at the osteodistraction site.

El-Bialy et al., 2008 in J Dent Res

LIPUS stimulation enhances the healing process of orthodontically-induced root resorption in humans.

El-Bialy et al., 2002 in Ann Biomed Eng

LIPUS enhances human gingival fibroblasts differentiation and neural differentiation of gingival stem cells.

Mostafa et al., 2009 in Archs Oral Biol

Histometric findings

Control | LIPUS
---|---

Inubushi T, Tanaka E, et al., 2013 in Bone

Histometric findings

Control | LIPUS
---|---

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Histometric findings

Control | LIPUS
---|---

Inubushi T, Tanaka E, et al., 2013 in Bone

Histometric findings

Control | LIPUS
---|---

Inubushi T, Tanaka E, et al., 2013 in Bone
**Effect of LIPUS on lateral tooth movement**

**Amount of tooth movement**

![Bar graph showing the amount of tooth movement](image)

- **Control**
- **LIPUS**

* p < 0.05

**Effect of LIPUS on lateral tooth movement**

**Micro-CT images**

- **Occlusal view**
- **Coronal view**

![Images by the instepXio SMX-225CT, SHIMADZU Co.](image)

Arai C, Tanaka E, et al., under consideration

**Effect of LIPUS on lateral tooth movement**

**Micro-CT images**

- **Analyses of bone mineral density (BMD) and bone volume fraction (BV/TV)**

**Coronal section at the middle of the root**

- **M1**: 1st molar; **M2**: 2nd molar; **M3**: 3rd molar; **B**: buccal; **P**: palatal; **M**: medial; **D**: distal

Blue mark indicates Tissue Volume (TV)
Red mark indicates Bone Volume (BV)

Arai C, Tanaka E, et al., under consideration

**Effect of LIPUS on lateral tooth movement**

**Fluorochrome labels of experimental tooth movement**

- **Calcein bone label**
- **Xylenol orange bone label**

![Images showing fluorochrome labels](image)

200μm

Arai C, Tanaka E, et al., under consideration

**Effect of LIPUS on lateral tooth movement**

**Results**

- **Body weight**
- **Intermolar width**

![Bar graphs showing results](image)

- **Control**
- **LIPUS**

* p < 0.05

**Effect of LIPUS on lateral tooth movement**

Arai C, Tanaka E, et al., under consideration
Effect of low-intensity pulsed ultrasound (LIPUS) during lateral tooth movement

Results

This bone formation is the compensatory response to lateral tooth movement, indicating that LIPUS enhances bone remodeling during tooth movement and can accelerate tooth movement.

Arai C, Tanaka E, et al., under consideration

Clinical Trial

The use of LIPUS to a patient with short roots of maxillary incisors

Case: 16Y 9M Female
Chief Complaints: Anterior crowding

Oral photographs before treatment

Problem list
1. Minor crowding of bimaxillary anterior teeth
2. Slight deep bite

Panoramic radiograph at initial stage

Dental X-ray photographs

Initial stage

Exposure protocol:

Time: 15 min per a day
Duration: 10 weeks
US properties:
Frequency: 1.0 MHz
Pulse rate: 20% (2 ms on and 8 ms off)
Intensity: 150 mW/cm²

Oral photographs before and after 10-week treatment

Today’s lecture objectives

1) to recognize the effectiveness of LIPUS on orthodontic tooth movement.
2) to apply the LIPUS in clinical orthodontic treatment.
Dental X-ray photographs

Initial stage

10-week treatment

Aevo system™ (1st intraoral LIPUS system)

- Hand-held electronics
- Easy-to-use at-home
- Rechargeable
- Displays treatment status

- Intra-oral appliance
  - 20 minutes/day
  - Dual/Single arch treatment
  - Intra-oral ultrasound gel

- In-clinic software
  - Activation
  - Treatment zone (teeth) selectivity
  - Displays usage compliance

Subject demographics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Per-Protocol Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1 (5.88%)</td>
</tr>
<tr>
<td>Female</td>
<td>16 (94.1%)</td>
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<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>19.3</td>
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<td>Standard Deviation</td>
<td>5.76</td>
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<tr>
<td>Minimum</td>
<td>12.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>30.3</td>
</tr>
</tbody>
</table>

Tooth movement measurement

- $d_0$: the first extraction space measurement
- $d_i$: the last extraction space measurement on either side
- $t$: the number of weeks between $d_0$ and $d_i$

- Tooth movement rate = \( \frac{d_i - d_0}{t} \)
- $r_{exp}$: tooth movement rate on the LIPUS side
- $r_{cont}$: tooth movement rate on the control side

- Percent change = \( \frac{r_{exp} - r_{cont}}{r_{cont}} \times 100\%

Subject demographics

1 - 007 23 year-old female
2 months difference
88% faster tooth movement with LIPUS

Before treatment

Two months after LIPUS exposure

Provided by prof. Tarek El-Bialy.
Summary of the clinical trial

Preliminary study results:

- Aevo System provides a statistically significant (p=0.016) increase in tooth movement rate, with an average percentage increase of 29.0% in tooth movement rate compared to the control.

- There was no increase in adverse events or pain reported for Aevo System as compared to the control (p<0.001).

LIPUS exposure can inhibit root resorption on the compression side without interference of tooth movement and enhance bone remodeling during tooth movement, resulting in the acceleration of tooth movement.

AAO Donated Orthodontic Services (DOS) Program

All that is missing is You!

- Introduced in 2009, the DOS program provides access to care for children in need. Access to quality orthodontic care is missing in many children's lives. The AAO DOS program mission is to serve eligible children without insurance coverage or that do not qualify for other assistance in their state of residence.

- The program has expanded and offers care to children nationwide in addition to the recognized state programs in Illinois, Indiana, Kansas, Michigan, New Jersey, North Carolina, Rhode Island, Tennessee, Texas and Virginia.

- In order to expand further, we need you to help us by volunteering to serve as a provider orthodontist or help identify orthodontists willing to lead efforts to establish a DOS chapter in your state.

- Stop by the DOS booth here in San Diego to learn more about the program or contact Ann Sebaugh at asebaugh@aaortho.org with questions.