

## Interdental Osteotomies Induce Regional Acceleratory Phenomenon and Accelerate Orthodontic Tooth Movement – An Animal Study

Ya-Ying Teng (鄧雅音), Jein-Wein Liou (劉人文)  
Department of Craniofacial Orthodontics  
Chang Gung Memorial Hospital, Linkou, Taiwan



### Introduction

Orthodontic tooth movement is a process of regional alveolar bone remodeling around teeth, which is alveolar bone resorption on the pressure side and alveolar bone deposition on the tension side. Either a postoperative systemic or regional increase of bone turnover rate and osteoporosity should be able to accelerate orthodontic tooth movement. However, it has not been well studied whether a smaller extent jaw bone osteotomy, such as an interdental osteotomy, would induce a systemic increase of baseline bone turnover rate, a regional increase of alveolar bone turnover rate only, or even no effects. The purpose of this experimental study was to study the intensity of interdental osteotomies on the changes of baseline bone turnover rate, alveolar bone turnover rate, alveolar bone porosity, and rate of postoperative orthodontic tooth alignment.

### Material and Method

Twelve adult male beagle dogs were randomly assigned into 2 groups. The control group (N=6) received orthodontic tooth alignment of the maxillary incisors, and the experimental group (N=6) received orthodontic tooth alignment of the maxillary incisors and interdental osteotomies between the maxillary 3rd incisor and canine on both sides (Fig. 1) at the same time when the orthodontic tooth alignment was commenced. The orthodontic tooth alignment was 3 months in both groups.

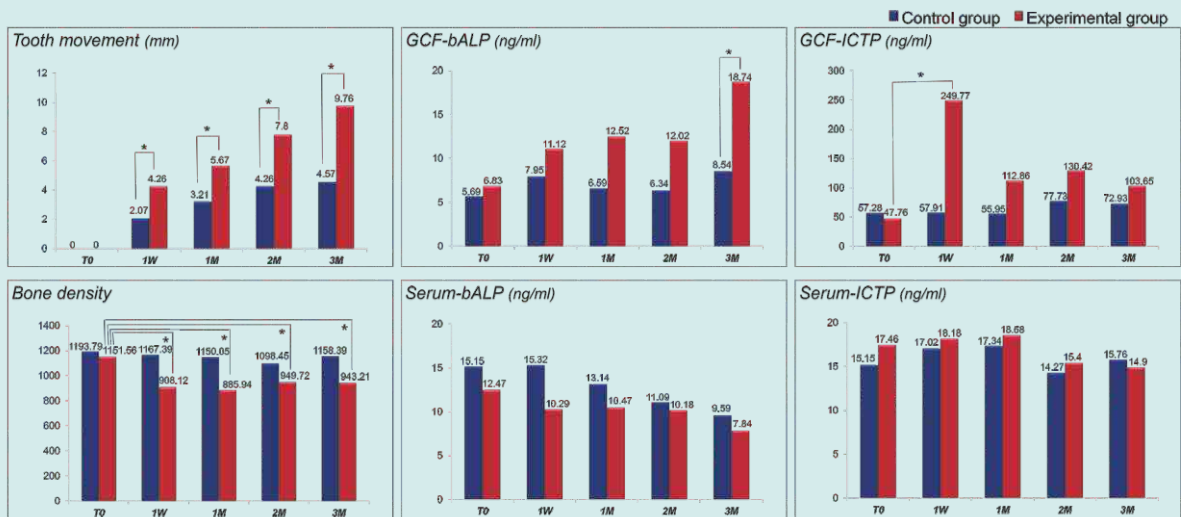
Records of cone beam CT of the maxilla, dental casts, blood samples, and gingival crevicular fluid (GCF) of the maxillary incisors were taken right before the orthodontic tooth alignment (T0), 1 week (T1), and 1 (T2), 2 (T3), 3 (T4) months after commencing the orthodontic tooth alignment. They were analyzed respectively for the changes of interdental alveolar bone gray scale (osteoporosity) of maxillary incisors, irregularity index (rate of orthodontic tooth movement), and the bone specific alkaline phosphatase (bALP) and C-terminal telopeptide of type I collagen (ICTP) in the serum and GCF samples from T0 to T4. The data were analyzed statistically for the inter- and intra-group differences.



**Fig. 1** Interdental osteotomy in the experimental group. (A,B) Interdental osteotomies were made with surgical carbide bur between the third incisor and canine on both sides. (C) The interdental osteotomies were cut through-and-through up to the incisive foramens and palatally to the palate.

## Result

The rate of orthodontic tooth alignment of the experimental group was significantly greater and 2-fold of that of the control group at T1, T2, T3, and T4. The serum-bALP, serum-ICTP, GCF-bALP, GCF-ICTP, and osteoporosity remained similarly from T0 to T4 in the control group. Whereas the GCF-bALP increased 2- to 3-folded from T1 to T4, the GCF-ICTP increased 5-folded at T1 then gradually decreased from T2 to T4, and the interdental osteoporosity significantly increased from T1 to T4, but the serum-bALP and serum-ICTP remained similar without significant changes in the experimental group.



## Conclusion

- ✓ Factors might affect the intensity of bone reactions after alveolar bone surgery, such as the extent of mucoperiosteal flaps, the type of alveolar bone surgery, study model or orthodontic tooth movement.
- ✓ This experimental study revealed that the interdental osteotomies did not induce a systemic increase of baseline bone but a mild to moderate regional increase of alveolar metabolism and alveolar bone porosity, which accelerated 2-folded faster the postoperative orthodontic tooth alignment.

## Interdental Osteotomies Induce Regional Acceleratory Phenomenon and Accelerate Orthodontic Tooth Movement – An Animal Study

Ya-Ying Teng (鄧雅音), Jein-Wein Liou (劉人文)  
 Department of Craniofacial Orthodontics  
 Chang Gung Memorial Hospital, Linkou, Taiwan

### Introduction

Orthodontic tooth movement is a process of regional alveolar bone remodeling around teeth, which is alveolar bone resorption on the pressure side and alveolar bone deposition on the tension side. Either a postoperative systemic or regional increase of bone turnover rate and osteoporosity should be able to accelerate orthodontic tooth movement. However, it has not been well studied whether a smaller extent jaw bone osteotomy, such as an interdental osteotomy, would induce a systemic increase of baseline bone turnover rate, a regional increase of alveolar bone turnover rate only, or even no effects. The purpose of this experimental study was to study the intensity of interdental osteotomies on the changes of baseline bone turnover rate, alveolar bone turnover rate, alveolar bone porosity, and rate of postoperative orthodontic tooth alignment.

### Material and Method

Twelve adult male beagle dogs were randomly assigned into 2 groups. The control group (N=6) received orthodontic tooth alignment of the maxillary incisors, and the experimental group (N=6) received orthodontic tooth alignment of the maxillary incisors and interdental osteotomies between the maxillary 3<sup>rd</sup> incisor and canine on both sides (Fig. 1) at the same time when the orthodontic tooth alignment was commenced. The orthodontic tooth alignment was 3 months in both groups.

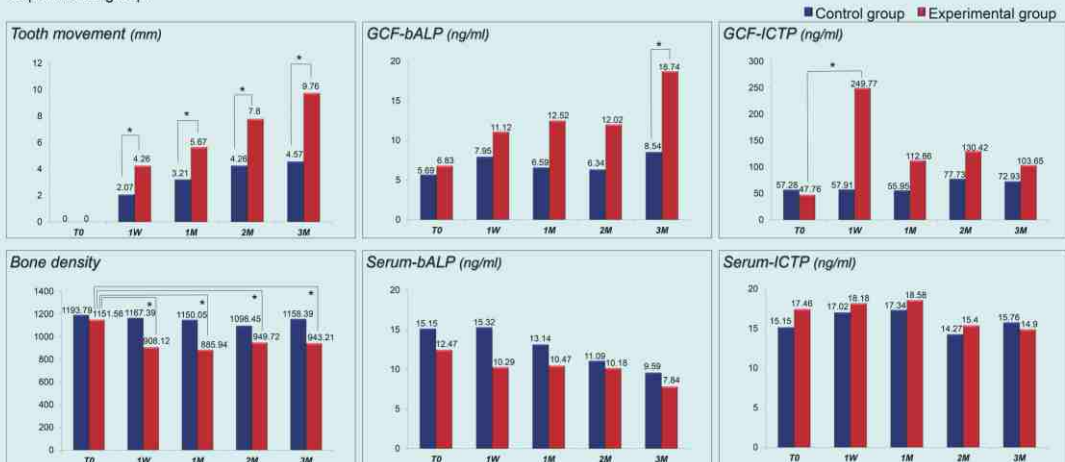
Records of cone beam CT of the maxilla, dental casts, blood samples, and gingival crevicular fluid (GCF) of the maxillary incisors were taken right before the orthodontic tooth alignment (T0), 1 week (T1), 1 (T2), 2 (T3), 3 (T4) months after commencing the orthodontic tooth alignment. They were analyzed respectively for the changes of interdental alveolar bone gray scale (osteoporosity) of maxillary incisors, irregularity index (rate of orthodontic tooth movement), and the bone specific alkaline phosphatase (bALP) and C-terminal telopeptide of type I collagen (ICTP) in the serum and GCF samples from T0 to T4. The data were analyzed statistically for the inter- and intra-group differences.



Fig. 1 Interdental osteotomy in the experimental group. (A,B) Interdental osteotomies were made with surgical carbide bur between the third incisor and canine on both sides. (C) The interdental osteotomies were cut through-and-through up to the incisive foramina and palatally to the palate.

### Result

The rate of orthodontic tooth alignment of the experimental group was significantly greater and 2-fold of that of the control group at T1, T2, T3, and T4. The serum-bALP, serum-ICTP, GCF-bALP, GCF-ICTP, and osteoporosity remained similarly from T0 to T4 in the control group. Whereas the GCF-bALP increased 2- to 3-folded from T1 to T4, the GCF-ICTP increased 5-folded at T1 then gradually decreased from T2 to T4, and the interdental osteoporosity significantly increased from T1 to T4, but the serum-bALP and serum-ICTP remained similar without significant changes in the experimental group.



### Conclusion

- ✓ Factors might affect the intensity of bone reactions after alveolar bone surgery, such as the extent of mucoperiosteal flaps, the type of alveolar bone surgery, study model or orthodontic tooth movement.
- ✓ This experimental study revealed that the interdental osteotomies did not induce a systemic increase of baseline bone but a mild to moderate regional increase of alveolar metabolism and alveolar bone porosity, which accelerated 2-folded faster the postoperative orthodontic tooth alignment.

# 壁報論文比賽作品 醫院組第二名

## Effects of localized Vitamin D3 Treatment on the Alveolar Bone Regeneration in Dogs

Hisao-Han Ho, Ting-An Chou, Hsiang-Hsi Hong

<sup>1</sup>Department of Periodontics, Chang Gung Memorial Hospital, Taoyuan, Taiwan;

<sup>2</sup>Department of Periodontics, Chang Gung Memorial Hospital, Taoyuan, Taiwan;

<sup>3</sup>College of Medicine, Chang Gung University, Taoyuan, Taiwan

### Background: Objectives:

Vitamin D3 plays an important role in the regulation of mineral homeostasis and bone metabolism. However, the regenerative effects of active vitamin D locally delivered on bony sockets are limited. The aim of the study was to explore the regenerative possibility of active vitamin D3 (calcitriol), which was applied locally to surgically created defects on the alveolar bones of Beagle dogs during the experimental period.

### Materials and Methods:

Designed sockets prepared on the mandibles of four Beagle dogs were divided into three groups according to the local treatment modalities: Calcitriol+Alloplast, Alloplast, and Empty. After a healing period of four weeks, the extent of vertical ridge resorption (VRR), bone density (Density), new bone formation (NBF) and initial implant stability quotient (ISQ) were measured.

### Statistical analysis:

Differences in NBF, Density, ISQ, and VRR between groups were analyzed using pairwise comparison.

	Calcitriol +Alloplast	Alloplast	Empty
<b>NBF (%)</b>	23.28±9.28	13.13±4.50	33.58±6.40
<b>Density (Hu)</b>	932.34±229.20	565.53± 229.91	1155.96±218.00
<b>ISQ</b>	74.31± 4.88	66.29± 7.02	73.67± 6.02
<b>VRR (mm)</b>	1.42±0.19	1.46±0.13	2.72±0.23

**Table 1** New bone formation (NBF), bone density (Density), initial implant stability quotient (ISQ) and the extent of vertical ridge resorption (VRR) in three subgroups

**Table 2** Comparison of NBF, Density, ISQ and VRR among various subgroups

NBF	Calcitriol +Alloplast	Alloplast	Empty	Density	Calcitriol +Alloplast	Alloplast	Empty
<b>Calcitriol +Alloplast</b>		<0.001***	0.012*	<b>Calcitriol +Alloplast</b>		<0.001***	0.018*
<b>Alloplast</b>			<0.001***	<b>Alloplast</b>			<0.001***

ISQ	Calcitriol +Alloplast	Alloplast	Empty	VRR	Calcitriol +Alloplast	Alloplast	Empty
Calcitriol +Alloplast		0.005	0.824	Calcitriol +Alloplast			<0.001***
Alloplast			0.142	Alloplast			<0.001***

### Results:

The Empty treatment revealed the highest value of NBF ( $33.58 \pm 6.40\%$ ) and Density ( $1156.96 \pm 218.00$ ), followed by the Calcitriol +Alloplast treatment (NBF:  $23.28 \pm 9.28\%$ ; Density:  $932.34 \pm 229.20$ ). The Alloplast treatment showed the least value on NBF ( $13.13 \pm 4.50\%$ ) and Density ( $565.53 \pm 229.91$ ) (Table1). In addition, the pairwise comparison between any two local treatments was significant ( $P < 0.05$ ) (Table2). The Calcitriol +Alloplast group revealed higher values of NBF ( $P < 0.001$ ), density ( $P < 0.001$ ), and ISQ ( $P = 0.05$ ) than the Alloplast group. The Empty group had significantly higher values of VRR than other two groups ( $P < 0.001$ ) (Table2).

### Conclusion:

Within the limitation of this animal research, studying the early healing characteristic of artificial defects, the data shows that the local vitamin D3 (Calcitriol) treatment can accelerate bone regeneration in dogs. The Empty group shows more vertical ridge resorption and better bony formation than other two groups. The result presents that alloplast could play a significant role on alveolar ridge preservation, however, may delay the bone remodeling process in the early healing period.

### Reference:

1. Kawakami M and Takano-Yamamoto T (2004) Local injection of 1,25-dihydroxyvitamin D3 enhanced bone formation for tooth stabilization after experimental tooth movement in rats. *J Bone Miner Metab* 22, 541–546.
2. Lidor, C., Dekel, S. & Meyer, M.S., Blaugrund E, Hallel T, Edelstein S (1990) Biochemical and biomechanical properties of avian callus after local administration of dihydroxylated vitamin D metabolites. *J Bone Joint Surg Br* 72, 137–140.
3. Takano-Yamamoto T, Kawakami M, Kobayashi Y, Yamashiro T, Sakuda M (1992) The effect of local application of 1,25- dihydroxycholecalciferol on osteoclast numbers in orthodontically treated rats. *J Dent Res* 71, 53–59.
4. Cardaropoli G, Araujo M, Hayacibara R, Sukekava F, Lindhe J. Healing of extraction sockets and surgically produced – augmented and non-augmented – defects in the alveolar ridge. An experimental study in the dog. *J Clin Periodontol* 2005;32:435–44
5. Omeroglu, H. Ates, Y. Akkus, O. Korkusuz, F. Bicimoglu, A. & Akkas, N. (1997) Biomechanical analysis of the effects of single high-dose vitamin D3 on fracture healing in a healthy rabbit model. *Arch Orthop Trauma Surg* 116, 271-274.

# Effects of localized Vitamin D<sub>3</sub> Treatment on the Alveolar Bone Regeneration in Dogs

Hsiao-Han Ho, Ting-An Chou, Hsiang-Hsi Hong

<sup>1</sup>Department of Periodontics, Chang Gung Memorial Hospital, Taoyuan, Taiwan;

<sup>2</sup>Department of Periodontics, Chang Gung Memorial Hospital, Taoyuan, Taiwan;

<sup>3</sup>College of Medicine, Chang Gung University, Taoyuan, Taiwan

**Background: Objectives:** Vitamin D<sub>3</sub> plays an important role in the regulation of mineral homeostasis and bone metabolism. However, the regenerative effects of active vitamin D locally delivered on bony sockets are limited. The aim of the study was to explore the regenerative possibility of active vitamin D<sub>3</sub> (calcitriol), which was applied locally to surgically created defects on the alveolar bones of Beagle dogs during the experimental period.

**Materials and Methods:** Designed sockets prepared on the mandibles of four Beagle dogs were divided into three groups according to the local treatment modalities: Calcitriol+Alloplast, Alloplast, and Empty. After a healing period of four weeks, the extent of vertical ridge resorption (VRR), bone density (Density), new bone formation (NBF) and initial implant stability quotient (ISQ) were measured.

**Statistical analysis:** Differences in NBF, Density, ISQ, and VRR between groups were analyzed using pairwise comparison.

**Results:** The Empty treatment revealed the highest value of NBF (33.58±6.40%) and Density (1156.96±218.00), followed by the Calcitriol +Alloplast treatment (NBF: 23.28±9.28%; Density:932.34±229.20). The Alloplast treatment showed the least value on NBF (13.13±4.50%) and Density (565.53±229.91)(Table1). In addition, the pairwise comparison between any two local treatments was significant (P<0.05)(Table2). The Calcitriol+Alloplast group revealed higher values of NBF (P<0.001), density (P<0.001), and ISQ (P=0.05) than the Alloplast group. The Empty group had significantly higher values of VRR than other two groups (P<0.001)(Table2).

**Conclusion:** Within the limitation of this animal research, studying the early healing characteristic of artificial defects, the data shows that the local vitamin D<sub>3</sub> (Calcitriol) treatment can accelerate bone regeneration in dogs. The Empty group shows more vertical ridge resorption and better bony formation than other two groups. The result presents that alloplast could play a significant role on alveolar ridge preservation, however, may delay the bone remodeling process in the early healing period.

**Table1** New bone formation (NBF), bone density (Density), initial implant stability quotient (ISQ) and the extent of vertical ridge resorption (VRR) in three subgroups

	Calcitriol +Alloplast	Alloplast	Empty
<b>NBF (%)</b>	23.28±9.28	13.13±4.50	33.58±6.40
<b>Density (Hu)</b>	932.34±229.20	565.53± 229.91	1155.96±218.00
<b>ISQ</b>	74.31± 4.88	66.29± 7.02	73.67± 6.02
<b>VRR (mm)</b>	1.42±0.19	1.46±0.13	2.72±0.23

**Table 2** Comparison of NBF, Density, ISQ and VRR among various subgroups

	Calcitriol +Alloplast	Alloplast	Empty
<b>NBF</b>			
Calcitriol +Alloplast		<0.001***	0.012*
Alloplast			<0.001***
<b>Density</b>			
Calcitriol +Alloplast		<0.001***	0.018*
Alloplast			<0.001***
<b>ISQ</b>			
Calcitriol +Alloplast		0.005	0.824
Alloplast			0.142
<b>VRR</b>			
Calcitriol +Alloplast			<0.001***
Alloplast			<0.001***

## Reference:

- 1.Kawakami M and Takano-Yamamoto T (2004) Local injection of 1,25-dihydroxyvitamin D<sub>3</sub> enhanced bone formation for tooth stabilization after experimental tooth movement in rats. *J Bone Miner Metab* 22, 541–546.
- 2.Lidor, C., Dekel, S. & Meyer, M.S., Blaugrund E, Hallel T, Edelstein S (1990) Biochemical and biomechanical properties of avian callus after local administration of dihydroxylated vitamin D metabolites. *J Bone Joint Surg Br* 72, 137–140.
- 3.Takano-Yamamoto T, Kawakami M, Kobayashi Y, Yamashiro T, Sakuda M (1992) The effect of local application of 1,25- dihydroxycholecalciferol on osteoclast numbers in orthodontically treated rats. *J Dent Res* 71, 53–59.
- 4.Cardaropoli G, Araujo M, Hayacibara R, Sukekava F, Lindhe J. Healing of extraction sockets and surgically produced – augmented and non-augmented – defects in the alveolar ridge. An experimental study in the dog. *J Clin Periodontol* 2005;32:435–44
- 5.Omeroglu, H. Ates, Y. Akkus, O. Korkusuz, F. Bicimoglu, A. & Akkas, N. (1997) Biomechanical analysis of the effects of single high-dose vitamin D<sub>3</sub> on fracture healing in a healthy rabbit model. *Arch Orthop Trauma Surg* 116, 271-274.

# 壁報論文比賽作品 醫院組第三名

## 以雷射掃描測量上顎及下顎第一小白齒牙根表面積

Root surfaces of maxillary and mandibular first premolar measured by dental laser scan

蘇育瑩(Yu-Ying Su) / 洪祥熙(Hsiang-Hsi Hong)

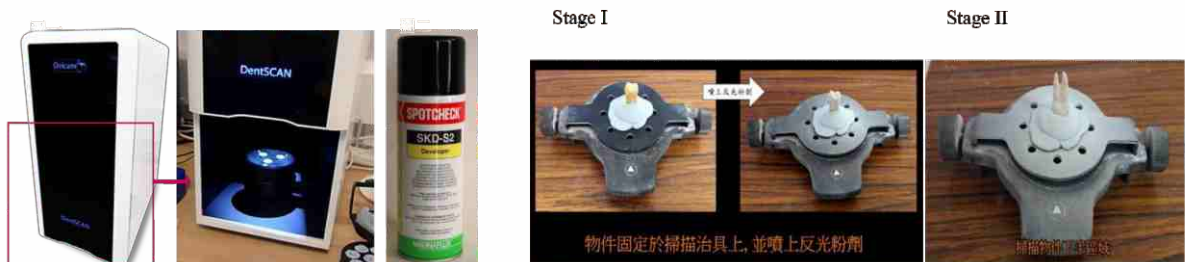
財團法人林口長庚醫院牙周病科 Department of Periodontology, Chang Gung University,  
Chang Gung Memorial Hospital Lin Kou Medical Center, Taiwan

### 背景

牙根表面積對於牙周組織支持能力有很大的相關性，不論是在牙周病學，矯正時牙齒的錨定量或是移動所需要的力量，甚至在製作固定式牙橋時都需要考慮。從1979年至今，有很多不同的學者使用不同的方式及設備來測量牙根表面積，但是方法都很費工耗時，或是樣本數不足，而沒有得到可信的成果。現今雷射掃描的技術越來越進步，本實驗在牙齒噴上粉末後，利用DentScan雷射掃描的機器掃描自然齒外型，本實驗之雷射光下可以顯示出精密度0.02mm的座標，也可以得到牙根表面3D立體的表面積其精確度為相當可信。

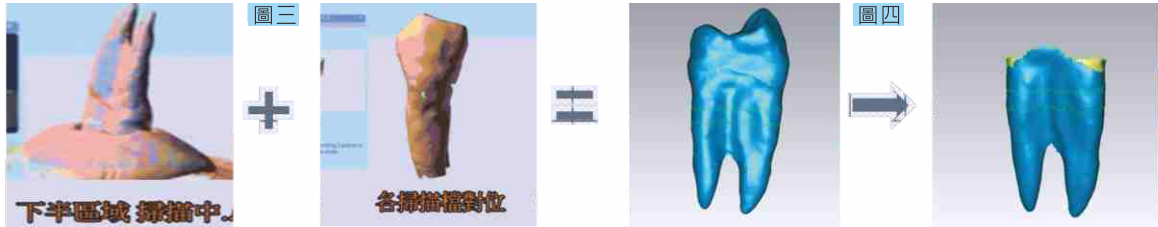
### 材料與方法

本實驗一共收集了34顆上顎第一小白齒，40顆下顎第一小白齒，使用DentSCAN (Delcam, Birmingham, UK) 設備進行掃描自然齒外型，擷取座標位置並加以計算表面積。其方式是將牙齒放置於可電腦控制之360度旋轉平台上，採用LED光柵照射於牙齒表面，並同時使用兩顆CCD鏡頭以不同角度擷取牙齒影像，採用兩顆CCD鏡頭位置為固定基線長度之三角量測法計算出牙齒表面的點(point)座標(X,Y,Z)，並配合旋轉平台角度，以擷取不同角度方向之牙齒表面座標值，此方式之優點可在1至2分鐘內，即可得到影像中的多個點群座標(cloud point)。(圖一為DentSCAN光柵掃描設備外觀圖)



因上述方式係採用光學影像技術擷取牙齒表座標資訊，為避免牙齒表面因為LED光柵照射時產生反射或折射現象，影響影像正確性，因此需事先在自然齒表面噴上一層白色粉末(圖二)。此外，為將牙齒固定於掃描平台上，牙齒固定區域(如牙根或牙冠)將無法成功擷取外型，因此必須採用兩階段擷取方式(圖三)，也就是第一階段先在牙根底部區域固定

於旋轉平台上，擷取牙冠與牙根中段以上區域，接著第二階段以牙冠區域固定於旋轉平台上，擷取牙根與牙冠露出區域，之後利用 DentSCAN 設備軟體將牙齒上、下兩個點群資料合併再一起，並移除牙冠部分 (圖四)；利用兩階段擷取方式須注意在各別上、下牙齒掃描時，必須要有重複區域 (通常為牙根中、上段處-CEJ)以作為上、下兩個點群資料合併時之位置參考依據。



### 結果

上顎第一小白齒(34顆)													下顎第一小白齒(40顆)																	
全齒 面積 (mm <sup>2</sup> )	牙根 (CEJ以 下)面積 (mm <sup>2</sup> )	牙根 (CEJ以 上)長度 (mm)	靠近牙 根尖處 75% 的牙根 表面積 (mm <sup>2</sup> )	靠近牙 根尖處 50% 的牙根 表面積 (mm <sup>2</sup> )	靠近牙 根尖處 25% 的牙根 表面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	H/B	全齒 面積 (mm <sup>2</sup> )	牙根 (CEJ以 下)面積 (mm <sup>2</sup> )	牙根 (CEJ以 上)長度 (mm)	靠近牙 根尖處 75% 的牙根 表面積 (mm <sup>2</sup> )	靠近牙 根尖處 50% 的牙根 表面積 (mm <sup>2</sup> )	靠近牙 根尖處 25% 的牙根 表面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	牙根表 面積 (mm <sup>2</sup> )	H/B					
	A	B	C	D	E	F	G	H	I	J	K	L		M	N	O	P	Q	R	S	T	U	V	W	X					
平均值	42.6	21.6	12.4	15.1	70.2%	8.9	41.2%	3.5	16.5%	9.9	80.2%	7.4	59.3%	4.4	35.5%	390	204	13.3	141	69.0%	81	39.7%	31	15.3%	10.7	80.4%	8.0	59.8%	4.8	35.1%
標準差	5.6	3.67	1.6	2.4	3.8%	1.6	3.9%	0.8	2.9%	1.4	1.4%	1.1	2.3%	0.78	2.9%	45	29	1.4	20	3.1%	14	3.2%	57	2.4%	1.1	1.7%	1.0	2.3%	0.7	2.6%

### 討論

結果顯示因為牙根的型態是椎狀的,所以越靠近CEJ部分的牙根表面積越大，我們也因類似結果: 在牙周支持組織吸收而露出25%牙根長度(從CEJ到根尖)時，attachment area在下顎第一小白齒只剩下69.0%，而上顎第一小白齒剩下70.2%，在牙周支持組織吸收而露出50%牙根長度(從CEJ到根尖)時，attachment area在下顎第一小白齒只剩下39.7%，而上顎第一小白齒剩下41.2%，在牙周支持組織吸收而露出75%牙根長度(從CEJ到根尖)時，attachment area在下顎第一小白齒只剩下15.3%，而上顎第一小白齒剩下16.5%。而推論在用PA-X光片來評估牙周狀況的預後時，如果是以線性關係來評估，往往會低估實際上的attachment loss。在廣復應用上面，則是可能會高估支台齒的支持能力。在矯正學方面，則是可能會因為高估牙根表面支持能力而施以過大的應力。

### 結論

由實驗的數據可以得知，當牙周組織失去25% periodontal attachment (牙根表面積)時，在根尖片 X-ray上看到的線性 bone loss高度是牙根 (從CEJ到根尖) 的80.1% (上顎第一小白齒)、80.4% (下顎第一小白齒)；當牙周組織失去50% periodontal attachment (牙根表面積)時，在根尖片 X-ray上看到的線性bone loss高度是牙根(從CEJ到根尖)的59.3% (上顎)、59.8% (下顎)；當牙周組織失去75% periodontal attachment (牙根表面積)時，在根

尖片 X-ray上看到的線性bone loss高度是 牙根 (從CEJ到根尖)的35.5% (上顎)、36.1% (下顎)。數據之間之統計上的意義，還需要進一步統計分析。其他牙位的牙齒 因為樣本數不夠多，數據收集強度較為不足，未來應該要收集更多樣本再加以研究。

#### **Reference:**

1. Prognosis Versus Actual Outcome: a long-term survey of 100 treated periodontal patients under maintenance care. McGuire MK1, Nunn ME. J Periodontol. 62:51,1991.
2. Prognosis Versus Actual Outcome.II. The Effectiveness of Clinical Parameters in Developing an Accurate Prognosis. McGuire MK1, Nunn ME. J Periodontol. 67:658, 1996
3. The relationship between attachment height and attachment area of teeth using a digitizer and a digital computer. Alan R. Levy, Wellesley H. Wright. J Periodontol. 49(9):483-485, 1979.
4. Root surface area of the mandibular cuspid and bicuspid. John K ,Mowry, MichaelG,Ching, Marc,D.Orjansen, Charles M.Cobb, Lynn Roosa Friesen, Simon R. MacNeill, and John W Rapley. J Periodontol. 2002 Oct;73(10):1095-100.
5. Accuracy of supported root ratio estimation from projected length and area using digital radiograph. Ssu-Kuang Chen, Ju-HingPan, Chung-Ming Chen, and Jeng-YwanJeng. J Periodontol. 2004 Jun;75(6):866-71.



