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人工植牙

拔牙後齒槽嵴保存術之生物基礎及其治療方式

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目的：

本篇文獻回顧主要針對拔牙後齒槽脊解剖及組織學上變化，包括水平及垂直吸收的量，並評估各種補骨術式及其成效。

結果：

2012學者Lang團隊分析所得，拔牙後6個月齒槽脊水平吸收（ 3.79 ± 0.23 mm），遠多過垂直吸收（ 1.24 ± 0.11 mm）。且3個月水平吸收為32%，6至7個月介於29～63%。2013學者Horvath團隊發表，分析多篇應用各種補骨材料施行齒槽脊保存術的成果，因各篇臨床實驗異質性極大，故無法做meta-analysis。結果如下：齒槽脊保存術的水平吸收介於（ 1.0 mm～ 3.5 ± 2.7 mm），而單純拔牙組則為（ 2.5 mm～ 4.6 ± 0.3 mm），齒槽脊保存後水平吸收較少，有統計上意義。各種術式差別不大，但似乎GBR術式最有效，于植牙時有較少比例須再做補骨。

結論：

1. 拔牙後齒槽脊保存術，可以有效減少骨頭水平和垂直吸收，但無法完全避免骨頭吸收。
2. 使用Osteoconductive- mineralized骨粉，如：Bio-Oss吸收較慢，無法促進傷口癒合，且殘留較多骨粉，但較能維持骨脊寬度，減少吸收。
3. 使用再生膜時若有軟組織覆蓋，效果較好。
4. Primary closure並非完全需要。
5. 因大部份研究其拔牙齒槽窩屬於完整的窩洞，非嚴重破壞的窩洞，因此並無足夠的證據支持拔牙後齒槽脊保存術後的植牙成功率優於拔牙後自然癒合的植牙成功率。
6. 事實上齒槽脊破壞嚴重時施行的補骨應稱為ridge augmentation齒槽脊增加術，而非僅指保存術而已，但針對拔牙後ridge augmentation齒槽脊增加術方面的臨床研究則相對較少。

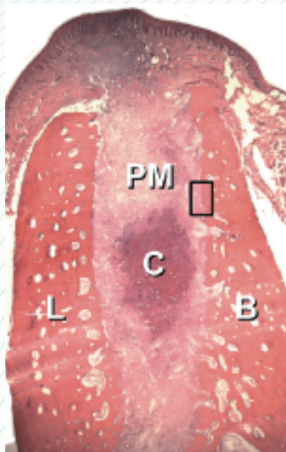


圖1：Overview of the extraction site after 1 week of healing. Note the large amounts

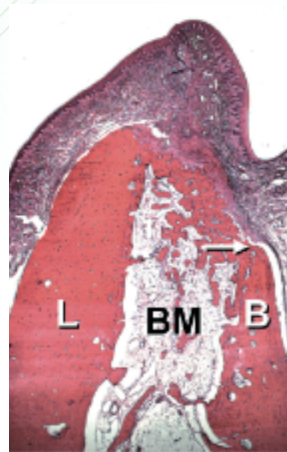


圖2：Overview of the extraction site after 8 weeks of healing. The entrance of the large amounts

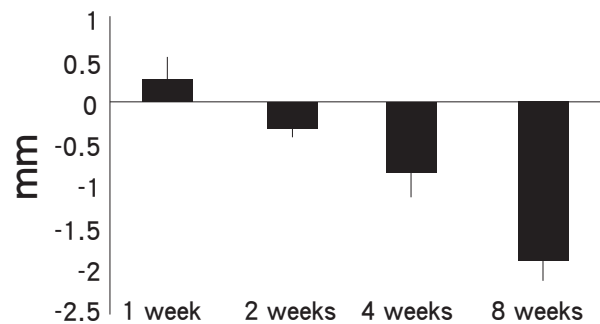


圖3

前言

牙齒拔除後，因解剖及生理上的變化，造成齒槽骨發生不可避免的吸收及塑形，從而影響到未來缺牙區植牙的治療。一般臨床上常見，利用拔牙窩洞補骨，冀望能達到齒槽嵴保存的目的。此治療模式的生物基礎尚未建立完整，且常遭誤解。本篇主要是文獻回顧，以釐清拔牙窩洞補骨術的成效，從而提供治療的原理及時機，予臨床醫師參考。

Alveolar Ridge Remodeling

上顎骨和下顎骨（maxillary and mandibular bony complex）是由幾個解剖構造組成，以維持其功能性和生理性。其組成如下：（i）basal bone—伴隨全身骨骼生長。形成mandible and maxilla的主體（ii）alveolar process—伴隨牙齒發育成長，並包含齒槽窩（iii）bundle bone—此為組織學上名詞，沿著齒槽窩並往牙冠方向形成頰側骨脊，有牙周韌帶穿過（Sharpey's fibers）¹。

牙齒拔除後，牙周組織萎縮，牙齒的附著構造（attachment apparatus 包含 cementum，periodontal ligament fibers and bundle bone）最先吸收^{2,3}。齒槽骨嵴則終其一生慢慢吸收塑形。Alveolar process remodeling 再塑形過程即會造成 vertical 和 horizontal bone loss 且往舌側移³。2005 年 Araujo 和 Lindhe 團隊在狗的實驗中發現，拔牙後，bundle bone 最先吸收，因 buccal crestal bone 大都為 bundle bone，且骨頭較薄，故 buccal side 吸收較多，造成水平和垂直方向吸收遠比舌側多，8 星期頰舌側可差 2.5mm。³（圖1～圖3）

人類前牙 buccal bone 平均只有 0.8mm，小白齒平均 1.1mm⁴。Schropp 團隊發現，一年約有 50% 水平吸收（相當於 6.1mm），其中 2/3 吸收（即 3.8mm）發生前 3 個月，之後慢慢吸收，可至一年才穩定，且 molar 吸收較 premolar 多⁵。Botticelli 團隊研究指出 Horizontal buccal bone 吸收可高達 56%，而 lingual 吸收約為 30%⁶，若拔牙過程中失去 buccal bone，則水平吸收更多^{2,7}。

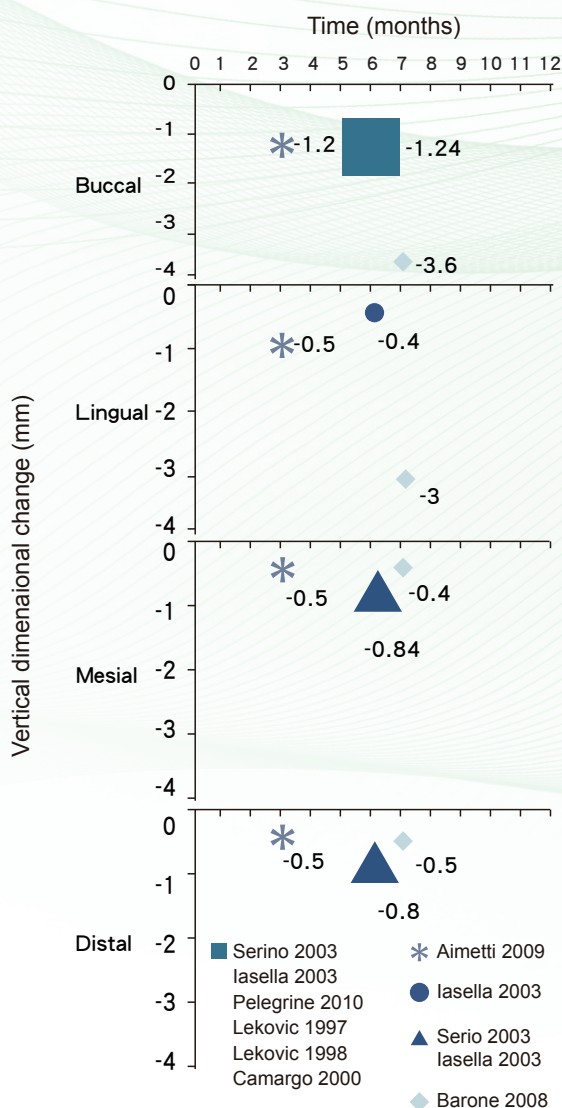


圖4：Vertical [linear] hard tissue change. for reentry studies only, weighted means shown.

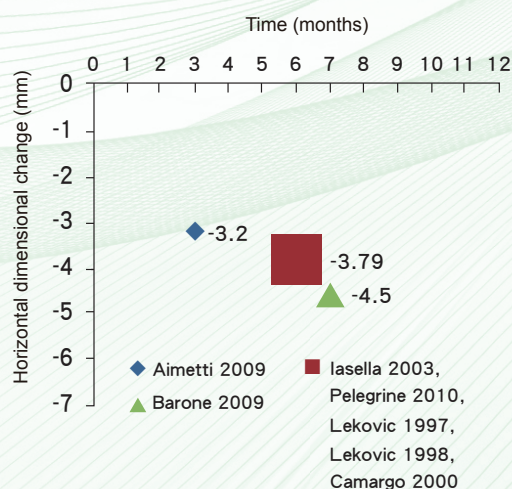


圖5：Horizontal [linear] hard tissue change for reentry studies only, weighted means shown.

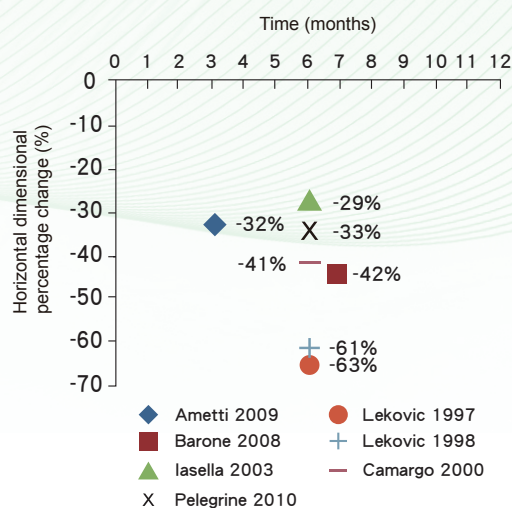


圖6：Horizontal [linear] hard tissue percentage change.

2012年Tan和Lang團隊⁸，針對人類拔牙後齒槽骨軟硬組織的改變，做的系統性回顧分析。共20篇符合條件來統計分析，其中17篇有關硬組織的變化，當中8篇利用re-entry（植牙時再翻開 flap）配合stent做測量^{7,9-15}。2010 Rasperini，則只利用stent來測量。另外8篇則用影像分析^{2,16-22}。

Vertical linear change垂直線性改變：3 months re-entry，buccal吸收 1.2 ± 0.8 mm，palatal吸收 0.9 ± 1.1 mm¹³，6 months re-entry，平均6個^{7,9,11,12,14,23} study weighted mean得到（ 1.2 ± 0.13 mm）⁸（圖4）骨頭吸收。

Horizontal linear change水平線性改變：8篇研究報告^{7,9-15}有關水平吸收研究，2008年 Kerr和2009年 Aimetti，3 months吸收2.20mm至 3.20mm^{13,20}，其他6篇^{7,9-12,14}，6 months吸收平均值 weighted mean 3.79 ± 0.23 mm⁸（圖5）。

Percentage of horizontal change水平吸收的百分比：共7篇研究，3 months吸收32%，6~7 months吸收29%~63%^{7,9-11,13-15}（圖6）。

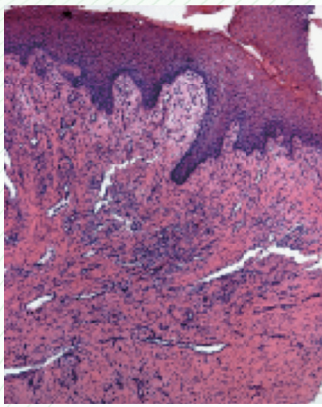


圖7：Early phase

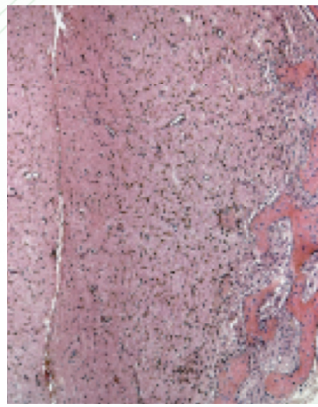


圖8：Intermediate phase

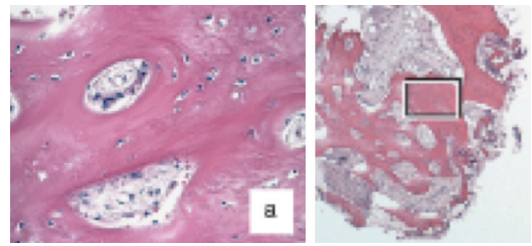


圖9：Late phase

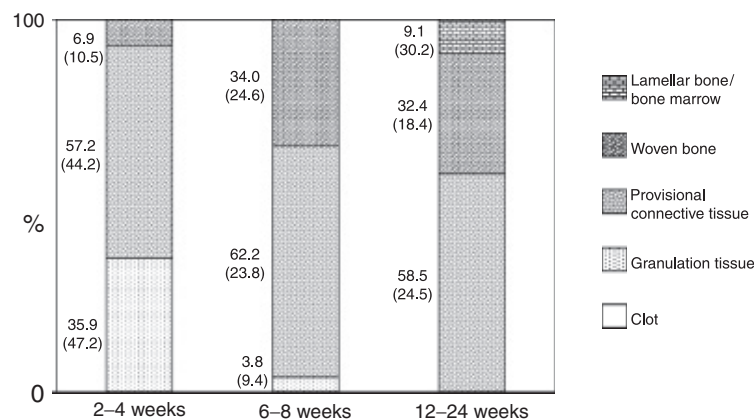


圖10：Distribution (mean%) of the tissue components (clot, granulation tissue, provisional connective tissue, woven bone, lamellar bone/bone marrow), calculated on all samples for each observation interval. The standard deviation is shown in percentage.

Socket healing 拔牙齒槽嵴癒合過程，2008 Trombelli²⁴：

牙齒拔除後，血塊形成，1 星期後慢慢形成顆粒組織

1. Early phase (2~4 weeks) 早期：以血管，纖維母細胞，及發炎細胞組成的顆粒組織所占据，且上皮細胞會慢慢移動，覆蓋在顆粒組織上（圖7）。
2. Intermediate healing phase 中間癒合期（6~8 weeks）：從拔牙窩洞的底部及側邊發生granulation tissue顆粒組織漸漸被provisional matrix臨時間質組織（包含間葉細胞、膠原纖維、血管及少數發炎細胞）取代，若鈣化過程發生，woven bone 波浪骨即形成（圖8）。
3. Late phase (12-24 weeks)：主要形成 lamellar bone and bone marrow 板狀骨和骨髓（圖9）。可參考各時期不同組織分佈比率（圖10）。

Immediate implant 立即植牙能預防齒槽嵴吸收嗎？不能

1991年Barzilay認為immediate implant可能可以減少甚至完全阻止齒槽嵴吸收，1996年在動物實驗上，得到立即植牙所新生的骨頭和一般植牙並無差別²⁵⁻²⁷。2000年後，多位學者的研究報告則持反

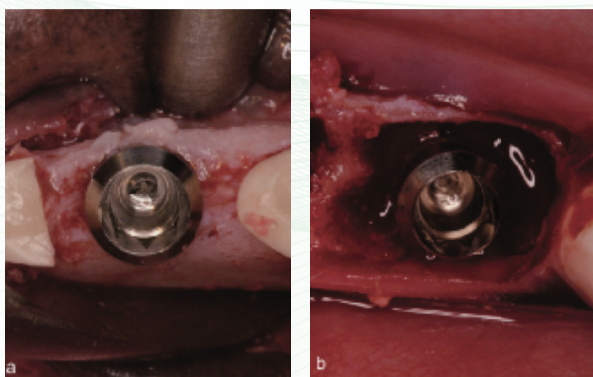


圖11

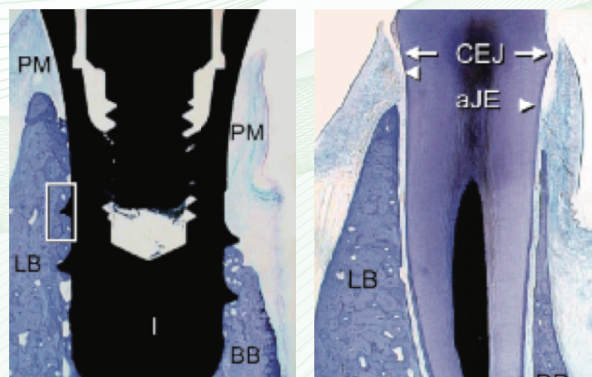
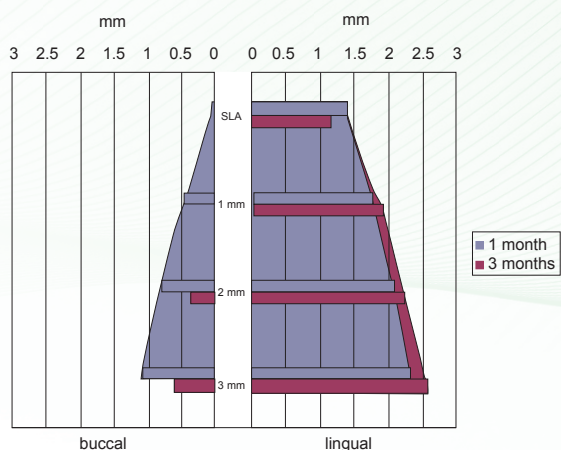
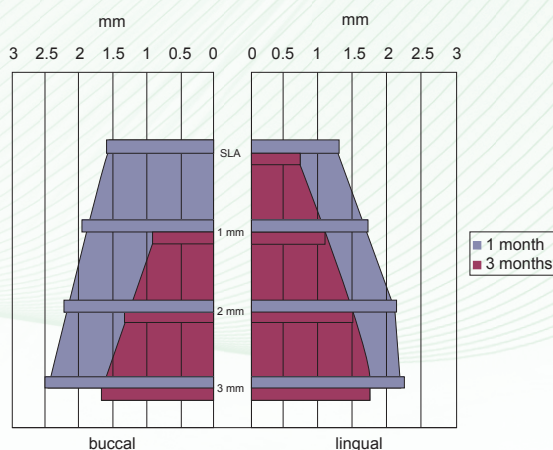


圖12



Premolar site. Schematic drawing describing the dimensions of the buccal and lingual bone walls

圖13：小白齒



Molar site. Schematic drawing describing dimensions of the buccal and lingual bone walls at different time intervals

圖14：大白齒

對意見。2004年Botticelli 研究中，21 immediate implant 沒放任何骨粉及membrane，其結果：植入時buccal bone和implant 中心距離 $3.4 \pm 0.7 \text{ mm}$ ，4 months 後翻開 flap，變成 $1.5 \pm 0.9 \text{ mm}$ ，約吸收 2.0mm（頰側），舌側由 $3.0 \pm 1.2 \text{ mm}$ 變成 $2.2 \pm 0.9 \text{ mm}$ ，約減少 0.8 mm（舌側）。Horizontal buccal bone 吸收可高達 56%，而lingual 吸收約為 30%⁶。Araujo，Botticelli and Lindhe 等研究團隊，發表一系列文章證明，立即植牙 3 months 後，buccal 和 lingual 的垂直高度，和一般拔牙後高度相似，也就是 buccal 垂直吸收比 lingual 多，約差 2mm^{6,28-31}，且大白齒吸收的量比小白齒多³⁰（圖11～圖14）。

Purposes of alveolar ridge preservation 齒槽嵴保存的目的 2012 Vignoletti³²：

1. 減少骨頭吸收。
2. 前牙區維持骨頭寬度，達到假牙美觀。
3. 維持適當的寬度，以利植牙植在假牙適當的位置。
4. 減少鼻竇手術的可能。
5. 減少額外補骨的可能。

齒槽嵴保存術（ARP）的禁忌：

1. 無法施行一般口腔手術的病人。
2. 感染。
3. 病人有接受過輻射治療。
4. 服用 bisphosphonates。

齒槽嵴保存術（ARP）的適應症

1. 無法立即植牙，也無法early implant placement的情況。
2. 需要為傳統假牙塑造骨頭外型。
3. 減少鼻竇手術的可能。

Intervention types of ridge preservation 齒槽嵴保存的術式：

1. Bone grafting 補骨術（自體骨粉或加PRGF，allograft 同種骨粉，異種骨粉如牛骨，人工骨粉，如硫酸鈣，bioactive glass，PG/PL sponge）
2. GBR 引導骨再生術（可吸收再生膜，不可吸收再生膜）
3. Biological active materials（growth factors）
4. Combinations

Alveolar ridge preservation 齒槽嵴保存術（以下簡稱 ARP）成效

2013 Horvath & Donos 團隊³³，及2012 Vignoletti³²及2011 Ten Heggeler³⁴所做的系統性回顧，結果如下：

Bone grafting：

(i) 4 篇有 re-entry 的研究報告^{10,12-14}，手術後觀察3到6個月

水平變化：ARP實驗組由-1.0 mm ~ -3.5 ± 2.7 mm，對照組-2.5mm ~ -3.2 ± 1.8 mm (p<0.05)，APR 比對照組吸收少，2009 Aimetti 和 2010 Pelegre 均認為有統計上意義^{13,14}。

垂直變化：正頰側，ARP 實驗組由+1.3 ± 1.9 mm ~ -0.5 ± 1.1 mm，對照組 -0.8 ± 1.6 mm ~ 1.2 ± 0.6 mm，2009 Aimetti 和 2010 Pelegre 均認為有統計上意義^{13,14}。

(ii) 2006 Nevin³⁵用cone beam CT 測量，前牙補 DBBM，手術後觀察1到4個月

水平變化：ARP實驗組 -2.42 ± 3.72 mm，對照組 -5.25 ± 3.72 mm (p<0.05)，APR實驗組比對照組吸收少，有統計上顯著意義，且71% 對照組的bone loss > 20%，相對的只有16% 的 APR 實驗組 (DBBM)，bone loss > 20%。

GBR 引導骨再生術：4篇中2篇只用再生膜，一個不可吸收再生膜，一個可吸收再生膜^{9,11}，另兩篇有加骨粉^{7,15}。觀察 4到9個月。

水平變化：ARP實驗組 -1.2 ± 0.9 mm ~ -2.5 ± 1.2 mm，對照組 -2.6 ± 2.3mm ~ -4.6 ± 0.3 mm (p<0.05)，使用 e-PTFE，PGPL 或 collagen 再生膜再加上 xenograft，APR實驗組比對照組吸收少，有統計上顯著意義^{9,11,15}。

垂直變化：正頰側，ARP實驗組 +1.3 ± 2.0 mm ~ -0.7 ± 1.4 mm，對照組 -0.9 ± 1.6 mm，4篇均認為 APR 實驗組比對照組吸收少，有統計上顯著意義。

Biological active materials (rhBMP-2, rhPDGF) 再生因子應用：2005 Fiorellini及2009 Nevins^{18,36}

2005 Fiorellini，應用collagen sponge 浸泡在0.75mg/ml 和1.50mg/ml 的rhBMP2，放置於buccal bone 破壞超過 50% 的上顎前牙，來和對照組相比，結果兩種濃度均有增加骨嵴寬度，有統計上意義，且 1.5mg/ml BMP實驗組增加較多。而其在組織學上觀察則和原本骨頭無異。

2009 Nevins，應用 rhPDGF 加上 Bio-Oss collagen 於上顎前牙拔牙位置，4 到 6 個月後，組織切片下觀察，4 個月 $23.2 \pm 3.2\%$ new bone，而殘餘的Bio-Oss 約 $9.5 \pm 9.1\%$ ，但6個月卻只有 $18.2 \pm 2.1\%$ new bone，而 Bio-Oss 約 $17.1 \pm 7.0\%$ ，等更久，並無更好。

Buccal Bone Overbuilding及Flap翻開的影響：

既然無法避免buccal bone的吸收，是否可以在buccal bone外側補骨，以減少吸收的量³⁷⁻³⁹。2000 Simon在狗的實驗，除了在拔牙窩洞內補骨，窩洞外也補骨再加上不可吸收再生膜，結果反而吸收約 40%，同樣2009 Fickl做狗的研究，利用bone spreader去撐裂骨頭，再去補骨，另一組拔牙後在buccal 外側做GBR，以達到overbuilding過度補骨的目的，去補償未來拔牙後bundle bone的吸收，結果只造成骨頭更加吸收。其最大可能原因是翻開flap，造成創傷，加上vertical incision，血液循環較差，故吸收較多。但若有放free gingival graft去覆蓋的實驗組，則骨頭吸收較少。另外Flapless 組，則有較少的骨頭吸收^{40,41}。

植牙成功置入於否

齒槽嵴保存術終極目的一植入理想尺寸的植體及完美的3D位置。多數的研究報告只提及植體植入，並未提及是否用較小尺寸植體，及是否有二次補骨⁴²。Sandor 團隊發現上顎前牙做完齒槽嵴保存術，仍有17.6% 需要二次補骨⁴³。Fiorellini et al.¹⁸，在拔除上顎前牙自然癒合的對照組發現，55%在植牙時須同時補骨，反而比齒槽嵴保存實驗組少。

討論

此篇文獻回顧發現，不論何種的齒槽嵴保存術，均無法完全減少拔牙後齒槽骨的萎縮，但施行齒槽嵴保存術可能可以減少骨頭吸收，其中施行GBR沒加骨粉術式，對減少水平吸收最多^{9,11}，而GBR加上骨粉，則對減少垂直吸收最佳^{7,15}。

臨床操作的意義：

施行齒槽嵴保存術的最大意義—減少未來需要二次補骨的機會，並植在完美位置。才能稱得上成功，否則就被視為沒必要，或算不成功。

結論^{33,44}

1. 牙齒拔除，一定會造成齒槽骨水平及垂直吸收。
2. 水平吸收比垂直吸收多。
3. 齒槽嵴保存術不能完全減少拔牙後齒槽骨吸收。
4. 齒槽嵴保存術可以減少一部分拔牙後骨頭吸收。
5. 完整齒槽窩存在，及primary flap closure 可以得到較好的結果。
6. 由於各式各樣的補骨材料，不同的術式，癒合時間不同，齒槽窩破壞程度不一，及大部分的實驗本極少，故很難做出判斷何種最好。但GBR術式似乎最有效，並置入吸收較慢的補骨材料，再加上primary closure，效果最佳。
7. 沒有證據證實，植牙置入齒槽嵴保存術的成功率比對照組高。
8. 目前的證據強度仍介在弱至中等程度，故需更多的實驗來印證此術式，應謹慎為之。

附記：附上臨床病例做參考

Case 1.

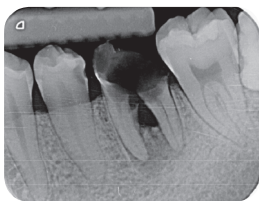


圖15：術前X光



圖16：術前口內照

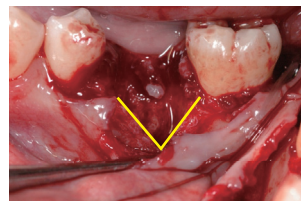


圖17



圖18



圖19：置入FDBA+ CaSO₄



圖20：加上CaSO₄ membrane



圖21：Primary closure



圖22

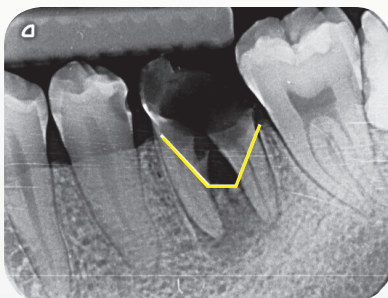
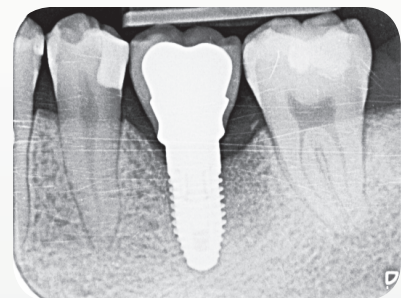
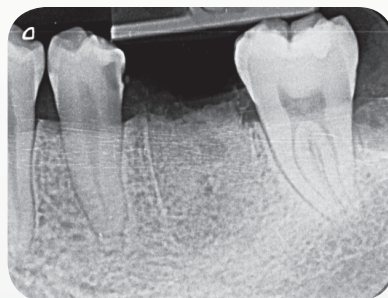


圖23：治療前後X光





黃X榕	FDBA+CaSO ₄
	%
Bone	63.16
Marrow	30.82
FDBA	6.02

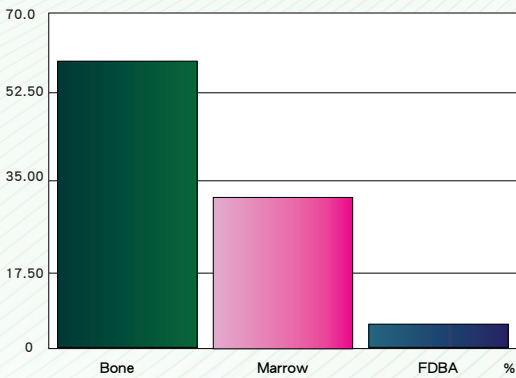


圖24：Histomorphometric analysis

Case 2.

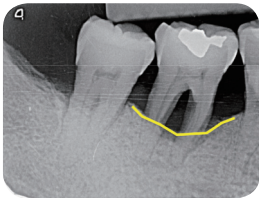


圖25：術前

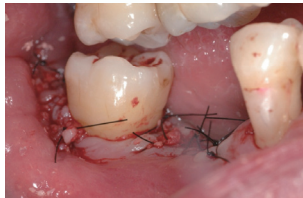
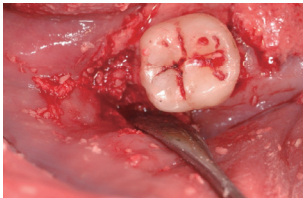


圖26：#47 distal GTR，#46 socket preservation – FDBA+CaSO₄+CaSO₄ membrane

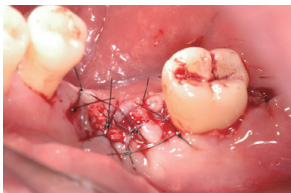


圖27：縫合

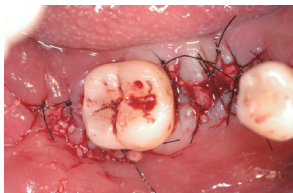


圖28：補骨後4 months，可見buccal bone resorption

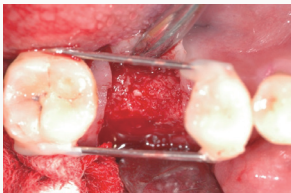


圖29：翻開 flap，水平吸收

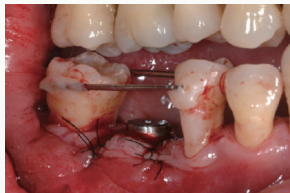
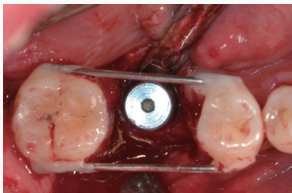
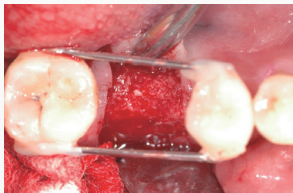


圖30：植入植體



圖31：術前

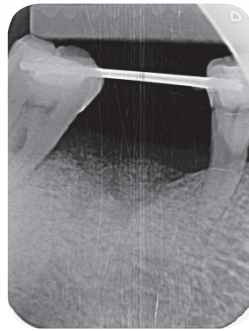


圖32：GBR 4months

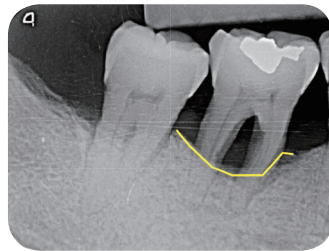


圖33：術前，術後X光

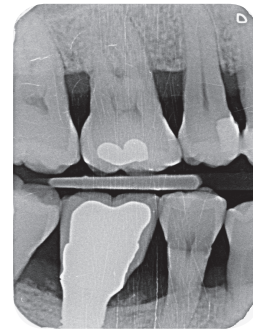
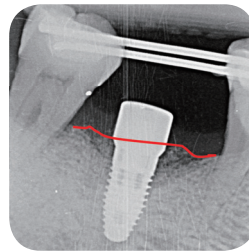


圖34：術後3年

Case 3.

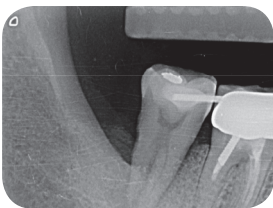


圖35：術前

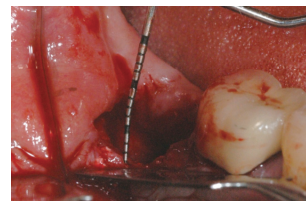


圖36：術中

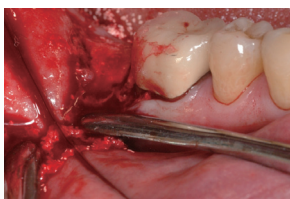
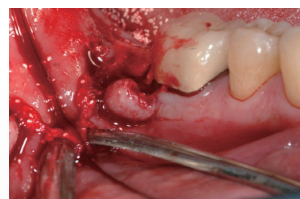


圖37：Bio-Oss + CaSO₄ for ridge preservation



圖38：術後一周拆線



圖39：術前、術後及ridge preservation 5個月

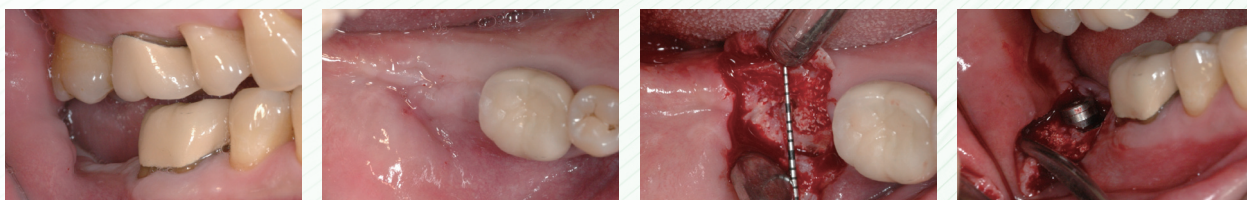


圖40：#47 implantation

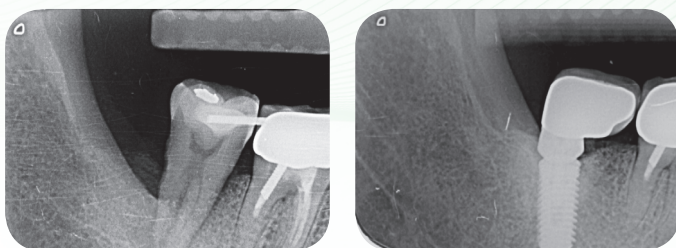


圖41：植牙前，植牙3年

附上圖表供參考³³

Table 3

First author Year of publication Type Design Methodology Reference number	Trial characteristics 1. Country 2. Number of centres 3. Setting	Population characteristics 1. Age range (mean) in years 2. Number of patients (sockets)	Confounding factors 1. Smoking 2. Periodontitis	Defect characteristics 1. Socket location 2. Defect morphology	Test material (number of sockets/ subjects)	Control (number of sockets/ subjects)	Surgical management 1. Type of flap 2. Soft tissue closure 3. Postoperative antimicrobials	Follow-up 1. Healing period 2. Number of drop-outs 3. Adverse events	Alveolar ridge dimension changes in horizontal width Mean/median mm 1. Whole ridge 2. Buccal plate	Alveolar ridge dimension changes in vertical height Mean/median mm (reference point) 1. Mid-buccal 2. Mesial 3. Distal 4. Socket Fill	Implant 1. Feasibility of implant placement 2. Necessity of simultaneous augmentation
Aimetti 2009 RCT Parallel Clin+Histo #42	1. Italy 2. 1 3. University	1. 36-68 (51.27 ±8.4) 2. 40 (40)	1. No 2. N/R	1. Maxillary anterior 2. 4-wall configuration	Calcium sulphate Hemihydrate (22/22)	Empty (18/18)	1. Flapless 2. No primary closure 3. Amoxicillin 2g/day for 5 days, Chlorexidine 0.12% for 2 weeks	1. 3 months 2. N/R 3. Uneventful healing	1. T: -2.0±1.1** C: -3.2±1.8**, *** 2. N/R	1. T: -0.5±1.1*, C: -1.2±0.6**, *** 2. T: -0.2±0.6, C: -0.5±0.9 3. T: -0.4±0.9, C: -0.5±1.1 4. T: 11.3±2.8** C: 10.0±2.3** (Acrylic stent)	1. Implants were inserted 2. N/R
Anitua 1999 CCT Parallel+Split- mouth Histo #43	1. Spain 2. 1 3. Private practice	1. T: 35-55 (41) C: 38-54 (42) 2. 23 (26)	1. Yes 2. Yes	1. Any 2. Variable	T1: PRGF (5+3/5+3) T2: PRGF+ Autologous bone (5/5)	Empty (10+3/ 10+3)	1. Full-thickness 2. Primary closure 3. Amoxicillin 1.5g/day for 5 days	1. 2.5 – 4 months 2. 0 3. N/R	N/A	N/A	1. N/R 2. N/R
Barone 2008 RCT Parallel Clin+Histo #21	1. Italy 2. 1 3. Hospital	1. 26-69 2. 40 (40)	1. <10/day 2. Yes (treated)	1. Non-molars 2. 4-wall configuration	Corticocancellous porcine bone+ collagen membrane (20/20)	Empty (20/20)	1. Full-thickness 2. Primary closure 3. Amoxicillin 2g/day for 4 days+ Chlorexidine 0.12% for 3 weeks	1. 7-9 months 2. 0 3. Uneventful healing (pain, swelling)	1. T: -2.5±1.2*, C: -4.5±0.8*, *** 2. N/R	1. T: -0.7±1.4*, C: -3.6±1.5*, *** 2. T: -0.2±0.8, C: -0.4±1.2 3. T: -0.4±0.8, C: -0.5±1.0 4. N/R (Acrylic stent)	1. 'Implants were inserted in both groups' 2. Some GBR were needed due to buccal dehiscence in the control group
Camargo 2000 CCT Split-mouth Clin #44	1. USA, Yugoslavia 3. University 2. N/R	1. 28-60 (44±15.9) 2. 16 (32)	1. N/R 2. N/R	1. Maxillary anterior, premolars 2. N/R	Bioactive glass+ covered by calcium sulphate layer (16/8)	Empty (16/8)	1. Full-thickness with 4 vertical releasing incisions 2. No primary closure 3. Penicillin 1.5g/day for 7 days+ Chlorexidine 0.12% for 2 weeks	1. 6 months 2. N/R 3. Uneventful healing	1. T: -3.48±2.68**, C: -3.06±2.41** 2. N/R	1. T: -0.38±3.18, C: -1.00±2.25 (titanium tack) 2. N/R 3. N/R 4. T: 6.43±2.78**, C: 4.00±2.33**, *** (to buccal bone crest)	1. Reentry only 2. N/A

Table 3 (continued)

First author Year of publication Type Design Methodology Reference number	Trial characteristics 1. Country 2. Number of centres 3. Setting	Population characteristics 1. Age range (mean) in years 2. Number of patients (sockets)	Confounding factors 1. Smoking 2. Periodontitis	Defect characteristics 1. Socket location 2. Defect morphology	Test material (number of sockets/ subjects)	Control (number of sockets/ subjects)	Surgical management 1. Type of flap 2. Soft tissue closure 3. Postoperative antimicrobials	Follow-up 1. Healing period 2. Number of drop-outs 3. Adverse events	Alveolar ridge dimension changes in horizontal width Mean/median mm 1. Whole ridge 2. Buccal plate	Alveolar ridge dimension changes in vertical height Mean/median mm (reference point) 1. Mid-buccal 2. Mesial 3. Distal 4. Socket Fill	Implant 1. Feasibility of implant placement 2. Necessity of simultaneous augmentation
Fiorellini 2005 RCT Parallel Radiogr+ Histo #20	1. USA 2. 8 centres 3. University	1. 47.4 2. 80 (95)	1. N/R 2. N/R	1. Maxillary anterior, premolars 2. ≥50% buccal bone loss	T1: 1.5mg/ml rhBMP-2 (?/21?) T2: 0.75mg/ml rhBMP-2 (?/22?) T3: Collagen sponge (?/17?)	Empty (?/20?)	1. Full-thickness with vertical incisions 2. Primary closure 3. Penicillin (?mg) for 7-10 days+ Chlorexidine 0.12%	1. 4 months 2. No drop-outs reported (3 patients incorrectly randomized, 1 patient received different graft) 3. 250 (T>C)	1. Coronal: T1: +3.27±2.53*, T2: +1.76±1.67*, T3: +0.82±1.40, C: +0.57±2.56, *** (T1 vs T2/T3/C) 2. N/R	1. T1: -0.02±1.2, T2: -0.62±1.39*, T3: -1.00±1.40*, C: -1.17±1.23*, *** (T1 vs C) 2. N/R 3. N/R 4. N/R	1. N/R 2. No need for augmentation: T1: 18/21 (86%) T2: 12/22 (55%) T3: 10/17 (59%) C: 9/20 (45%) (T1 vs T2/C)***
Frouin 2002 RCT Split mouth Histo #17	1. USA 2. Single centre 3. University	1. 35-77 (54.9±11.9) 2. 19 (30)	1. No 2. N/R	1. Any 2. 4-wall configuration, ≤2mm buccal plate loss	T1: Bioactive glass (10/8) T2: DFDBA (10/8)	Empty (10/10)	1. Full-thickness without vertical incisions 2. Primary closure 3. Doxycycline 100mg/day for 13 days+ Chlorexidine 0.12% for 30 days	1. 6-8 months 2. 0 3. Uneventful healing	N/A	N/A	1. 'An implant of appropriate size was placed in the healed sockets.' 2. N/R
Guarnieri 2004 CCT Parallel+ Split mouth Histo #45	1. Italy 2. N/R 3. N/R	1. 35-58 2. 10 (25)	1. N/R 2. Yes	1. Maxillary, mandibular anterior, premolars 2. socket with ridge resorption ≥50% were excluded	Calcium sulphate Hemihydrate (10/10)	Empty (5/5)	1. Full-thickness without vertical incisions 2. Primary closure 3. Amoxicillin (?mg) for 1 week+Chlorexidine 0.2% for 2 weeks	1. 3 months 2. N/R 3. N/R	N/A	N/A	1. 'Bucco-lingual dimensions of the alveolar ridge enabled safe insertion of titanium implant.' 2. N/R
Isella 2003 RCT Parallel Clin+Histo #23	1. USA 2. N/R 3. N/R	1. 28-76 (51.5±13.6) 2. 24 (24)	1. Yes 2. N/R	1. Maxillary anterior, premolars and mandibular premolars 2. N/R	Tetracycline hydrated FDBA + collagen membrane (12/12)	Empty (12/12)	1. Full-thickness without vertical incisions 2. No primary closure 3. Doxycycline 200mg/day for 1 week+ Chlorexidine 0.12% for 2 weeks	1. 4 or 6 months (combined) 2. 0 3. N/R	1. T: -1.2±0.9*, C: -2.6±2.3* 2. N/R	1. T: +1.3±2.0, C: -0.9±1.6*** 2. T: -0.1±0.7, C: -1.0±0.8*** 3. T: -0.1±0.7, C: -0.8±0.8*** 4. N/R (Acrylic stent)	1. Implants successfully placed at all sites 2. Some sites had slight dehiscence and required further augmentation

根管治療

口腔診斷與病變

一般牙科

人工植牙

口腔雷射

美容牙科

Table 3 (continued)

First author Year of publication Type Design Methodology Reference number	Trial characteristics 1. Country 2. Number of centres 3. Setting	Population characteristics 1. Age range (mean) in years 2. Number of patients (sockets)	Confounding factors 1. Smoking 2. Periodontitis	Defect characteristics 1. Socket location 2. Defect morphology	Test material (number of sockets/ subjects)	Control (number of sockets/ subjects)	Surgical management 1. Type of flap 2. Soft tissue closure 3. Postoperative antimicrobials	Follow-up 1. Healing period 2. Number of drop-outs 3. Adverse events	Alveolar ridge dimension changes in horizontal width Mean/median mm 1. Whole ridge 2. Buccal plate	Alveolar ridge dimension changes in vertical height Mean/median mm (reference point) 1. Mid-buccal 2. Mesial 3. Distal 4. Socket Fill	Implant 1. Feasibility of implant placement 2. Necessity of simultaneous augmentation
Lekovic 1997 CCT Split-mouth Clin #24	1. Yugoslavia / USA 2. N/R (presumably single centre) 3. University	1. (49.8) 2. 10 (20)	1. N/R 2. N/R	1. Maxillary and mandibular anterior, premolars 2. N/R	e-PTFE membrane (10/10)	Empty (10/10)	1. Full-thickness with 4 vertical releasing incisions 2. Primary closure 3. Penicillin 1g/day for 7 days+ Chlorexidine 0.2%	1. 6 months 2. 3/10 drop-outs due to premature membrane exposure 3. 3/10 exposed, 7/10 no infection	1. 10/10; T: -1.80±0.51, C: -4.40±0.61**, *** 7/10: T: -1.71±0.75, C: -4.43±0.72**, *** 3/10: T: -2.00±0.00, C: -4.33±0.88* 2. N/R	1. 10/10; T: -0.5±0.22, C: -1.2±0.13**, *** 7/10: T: -0.28±0.18, C: -1.0±0.0**, *** 3/10: T: -1.0±0.58, C: -1.66±0.33 (titanium tack) 2. N/R 3. N/R 4. 10/10: T: 4.9±0.86*, C: 3.0±0.63, *** 7/10: T: 5.43±1.1*, C: 2.92±1.61,*** 3/10: T: 3.66±1.20, C: 4.33±1.45 (to buccal bone crest)	1. Reentry only 2. N/A
Lekovic 1998 RCT Split-mouth Clin #25	1. Yugoslavia 2. 1 / USA 3. University	1. (52.6±11.8) 2. 16 (32)	1. N/R 2. Yes (treated)	1. Maxillary and mandibular anterior, premolars 2. N/R	PG/PL membrane (16/16)	Empty (16/16)	1. Full-thickness with 4 vertical releasing incisions 2. Primary closure 3. Penicillin 1g/day for 7 days+ Chlorexidine 0.12% for 2 weeks	1. 6 months 2. 0 3. Uneventful healing	1. T: -1.31±0.24*, C: -4.56±0.33*, *** 2. N/R	1. T: -0.38±0.22, C: -1.50±0.26*, *** (titanium tack) 2. N/R 3. N/R 4. T: 5.81±0.29*, C: 3.94±0.35*, *** (to buccal bone crest)	1. Reentry only 2. N/A
Neveins 2006 RCT Split-mouth Radiogr+ Histo #46	1. USA / Italy 2. N/R 3. N/R	1. N/R 2. 9 (36)	1. N/R 2. Yes	1. Maxillary anterior 2. Buccal plate was compromised	DBBM (19/9)	Empty (17/9)	1. Partial thickness 2. Primary closure 3. N/R	1. 1 – 3 months (biopsies at 6M) 2. 0 3. N/R	N/A	1. T: -2.42±2.58, C: -5.24±3.72*** 2. N/R 3. N/R 4. N/R (At 6 mm ridge width)	1. Implants were placed, but number unknown 2. N/R

Table 3 (continued)

First author Year of publication Type Design Methodology Reference number	Trial characteristics 1. Country 2. Number of centres 3. Setting	Population characteristics 1. Age range (mean) in years 2. Number of patients (sockets)	Confounding factors 1. Smoking 2. Periodontitis	Defect characteristics 1. Socket location 2. Defect morphology	Test material (number of sockets/ subjects)	Control (number of sockets/ subjects)	Surgical management 1. Type of flap 2. Soft tissue closure 3. Postoperative antimicrobials	Follow-up 1. Healing period 2. Number of drop-outs 3. Adverse events	Alveolar ridge dimension changes in horizontal width Mean/median mm 1. Whole ridge 2. Buccal plate	Alveolar ridge dimension changes in vertical height Mean/median mm (reference point) 1. Mid-buccal 2. Mesial 3. Distal 4. Socket Fill	Implant 1. Feasibility of implant placement 2. Necessity of simultaneous augmentation
Pelegreine 2010 RCT Parallel Clin+histo #47	1. Brazil 2. 1 3. University	1. 28-70 (47.5±10.3) 2. 13 (30)	1. No 2. N/R	1. Maxillary anterior 2. Sockets with severe bone loss were excluded	Autologous bone marrow (15/7)	Empty (15/6)	1. Full-thickness with 2 buccal vertical releasing incisions 2. Primary closure 3. N/R	1. 6 months 2. 0 3. Uneventful healing	1. T: -1.0*, C: -2.5*, *** 2. T: -0.75, C: -1.75, ***	1. T: -0.5*, C: -1.0*, *** (Titanium screw) 2. N/R 3. N/R 4. T: 10.33*, C: 10.32* (to buccal bone crest)	1. All implants osseointegrated 2. T: without further augmentation, C: At 5 sites augmentation or expansion carried out
Serino 2003 CCT Parallel+ split-mouth Clin+Histo #19	1. Italy 2. 1 3. N/R	1. 35-64 2. 45 (39) before drop-out	1. N/R 2. Yes (treated)	1. Any 2. Buccal plate could be partially or completely lost	PG/PL sponge (26/24) after drop-out	Empty (13/12) after drop-out	1. Full-thickness buccally and lingually 2. No primary closure 3. No antibiotics; Chlorexidine 0.2% for 2 weeks	1. 6 months 2. 9 drop-outs for reasons unrelated to the therapy 3. Uneventful healing	N/A	1. T: +1.3±1.9*, C: -0.8±1.6 2. T: -0.2±1.0, C: -0.6±1.0 3. T: -0.1±1.1, C: -0.8±1.5 4. N/R (Acrylic stent)	1. Placement of implants in all C and T sites with good primary stability 2. N/R
Serino 2008 CCT Parallel Histo #48	1. Italy 2. 1 3. N/R	1. 32-64 2. 20 (20) before drop-out	1. N/R 2. Yes (treated)	1. Any non-molars 2. Alveolar bone height ≥8mm	PG/PL sponge (7/7) after drop-out	Empty (9/9) after drop-out	1. Full-thickness buccally and lingually 2. No primary closure 3. No Antibiotics; Chlorexidine 0.2% for 2 weeks	1. 3 months 2. 4 drop-outs for reasons unrelated to the therapy 3. Uneventful healing	N/A	N/A	1. Placement of implants in all C and T sites with good primary stability 2. N/R

* $p < 0.05$; statistically significant intra-group difference, baseline to final; ** $p < 0.001$ statistically highly significant intra-group difference, baseline to final; *** $p < 0.05$ statistically significant inter-group difference, between test and control;
N/A not applicable; N/R not reported; T test; C control; M=month(s); Clin clinical analysis; Histo histological analysis; Radiogr radiographic analysis; RCT randomised controlled trial; CCT controlled clinical trial; PRGF plasma rich in growth factors; DFDBA demineralised freeze-dried bone allograft; FDBA freeze-dried bone allograft; e-PTFE expanded-polytetrafluorethylen; PG/PL polyglycolide/poly lactide; DBBM demineralised bovine-bone mineral

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Profile



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