Comparison of Er:YAG Laser Flapless Crown Lengthening vs. Open-Flap Bur Approach in Animal Studies

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Although predictable esthetic results of crown lengthening-related"gummy smile" correction can be achieved, the extended healing time associated with conventional surgical techniques can prove disadvantageous. Thus attempts were made to shorten the healing time by using different surgical devices such as piezosurgery instruments and erbium lasers. Piezosurgery is a less traumatic device compared to rotary instruments. However, with such instrumentation, there remains a need to apply open-flap surgery to perform CL. Flap raising lengthens healing time. Once the periosteum is separated from the underlying cortical bone, host inflammatory response pathways are stimulated and initiated. Cortical bone blood supply is interrupted, predisposing to resorption of the outer bony cortex. Pain, edema, and inflammation accompany flap surgery. Thus, a method to avoid flap raising would avoid these disadvantages. Dental hard-tissue lasers have been found to be less traumatic when compared to other surgical devices. Dental lasers have been used for crown lengthening procedures during the last two decades. Techniques to perform closed-flap crown lengthening to promote postoperative comfort and uneventful healing are proposed.

KEYWORDS

laser, erbium, Er:YAG, bur, crown lengthening, gummy smile, smile design, flapless surgery, animal study

Abstract

照慣例來說，牙冠增長術的完成是靠牙周翻瓣跟旋轉器械才達到的。中度-遠紅外線波長的介紹e.g.，erbium:YAG (2940nm) 已經可以達到許多優點，如：平靜的癒合，較少的水腫，不用縫線等等，在不翻瓣的牙冠增長術。不翻瓣的手術是屬於盲中進行的步驟，與上端環狀骨頭的塑型的完成是不確定的。

此研究的目的是為了比較羊骨手術方式後，骨頭質地變化。

新鮮的羊下顎常常被用來當作實驗手術，用兩側下顎4顆的大臼齒來做牙冠增長術比較，隨機地，一側用於測試組，一側用於控制組。Er:YAG laser (15Hz frequency, 400mJ energy, 200 μsec pulse duration 6 W average power) 被用來當測試組，沒有翻瓣，移除每顆牙齒的頰側骨脊2mm高。使用雷射後，每一處牙脊要用 Gracey curettes 打平滑，順便牙根刮除術也使用。控制組使用傳統的牙冠增長術：頰側骨脊2mm高用 800rpm round diamond bur 在生理食鹽水下移除，也使用 Gracey curettes 牙根刮除術.手術最後，測試組要翻瓣。使用 high-durometer silicone die material 印模。印模塊要單一尺寸，石膏被翻模後也要單一尺寸，方便在解析度15,500下掃描。用電腦軟體分析數據，眼睛可以看到的表面質地的比較用一般數位影像可以處理，微觀的，要用一般三角與點之間的線形的演算法 ("current triangles" and "current vertices.") 來分析。

兩組顯示相似的特徵在巨觀上，但是微觀裡，也沒有明顯的因果關係在一般三角與點之間的線形的演算法。

巨觀上，兩種方法有相類似的骨頭表面變化，Er:YAG laser 在顯微鏡下製造比較多的粗糙面在骨頭.研究結論證明 Er:YAG laser 的不翻瓣的手術比傳統上是有影響力的。考慮到不翻瓣的優點，是比傳統上的牙冠增長術來的好。

Materials And Methods

用十組新鮮乾淨的羊下顎來做實驗。用兩側下顎4顆的大臼齒來做牙冠增長術比較。隨機地，一側用於測試組，一側用於控制組。

測試組使用柔觸水雷射™ (LiteTouch™, 以色列) pulse duration, 400mJ energy per pulse, 15-Hz frequency, 6W average power output。無軟組織翻瓣，研究的目的是為了調查骨頭環狀部的區域。80-degree, 600-micron curved laser tip (312-9069, HoyaConBio)，標記2mm與4mm深度，每顆牙齒放進頰側骨頭環狀部2mm深移除骨頭部分，使用雷射過後，再使用 Gracey curettes 與牙根刮除術在每個骨頭部位使之平滑.在此步驟結束時，將牙齦翻瓣，檢測表面轉換變化。(Figure 1)

控制組經歷不同組合的翻瓣手術（靠著牙周粘膜的切開，並沒有建立一個新的游離牙齦邊緣）使用 2-mm diameter round

diamond bur 將2mm的頰側骨脊移除。操作者在生理食鹽水沖洗下，使用20:1 reduction contra-angle handpiece 800 rpm。之後再使用 Gracey curettes 作 1 to 2mm 的平滑斜線在冠部骨頭平滑與沿著暴露出的牙根實施牙根刮除術。(Figure 2)

在作者的經驗，牙冠增長術的失敗應該歸咎於不適當維護原來的上皮與結締組織間的生物距離（生物寬度）到骨脊，軟組織傾向原來的位置。結締組織對於骨頭與牙根的粗糙表面接觸得相當快，結合也相當強壯，因為纖維網絡附著接觸到粗糙表面帶有凝血與之後的發炎癒合機制。

然而，避免結締組織牙冠部的移動，最好是使骨頭與牙根上端環部的區域平滑。

使用 (Nikon D100 camera, f/22 diaphragm, 1/125 sec exposure, 105-mm macro lens) 一般設定拍攝每個 sample 的巨觀呈現。呈現與不呈現上端環部片狀骨切手術，大約2mm寬，在拍攝中皆可發現。

用 high-density silicone die material (Quick-DieTM, Bisco, Inc., Schaumburg, Ill., USA) (Figure 3) 取模在暴露的手術區. 使塊狀模型單一尺寸 (10x28-mm surface) (Figure 4)。石膏模型被製作，然後修至單一尺寸，再拿去掃描，在15,500解析度下使用 Maestro 3D Easy Dental Scanner，AGE Solutions S.r.l., Pisa, Italy。用視線探測一般數位影像來分辨巨觀表面質地。微觀表面特質被呈現於 "current triangles" and "current vertices" 與用 the Pearson correlation test 統計比較。(Figures 5-6)

點陣化是掃描工作的過程，取影像的任務描述在 vector graphics format (shapes) 與轉換至點陣影像 (pixels or dots) 為了輸出在影像呈現或者印表機，或者處存在 bitmap file format。最基本的點陣演算法採用3-D影像，如 polygons，然後使3-D影像轉成2-D平面影像，在電腦平面上，Polygons 呈現在三角演算法叢集。三角演算法被呈現在三維空間。在基本概念中，點陣化者採用點之間的線形，轉換成2-D平面影像在視者的顯示器中，填滿轉換成適當的2-D平面影像。

Figure 1: Sample of test group bone topography after flap reflection

Figure 2: Sample of control group bone topography

Figure 3: Test and control group mandibles. Impression pastes on operated areas are secured by plastic bases

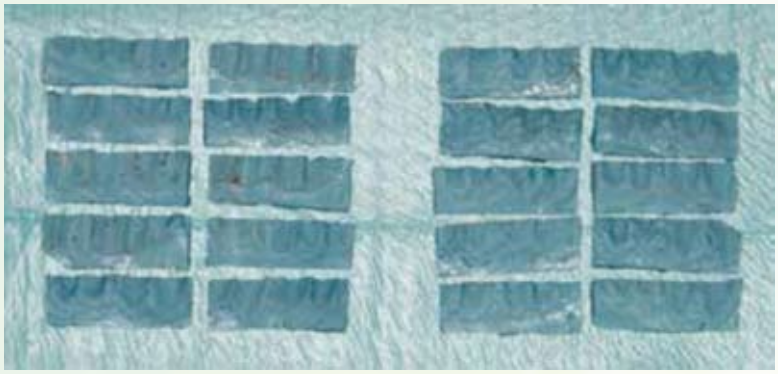

Figure 4: Impressions of control group (left side) and test group (right side)

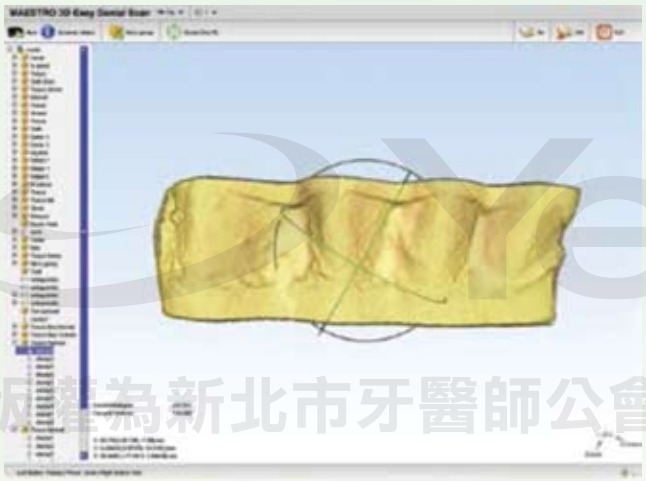

Figure 5: Scanned sample of test group

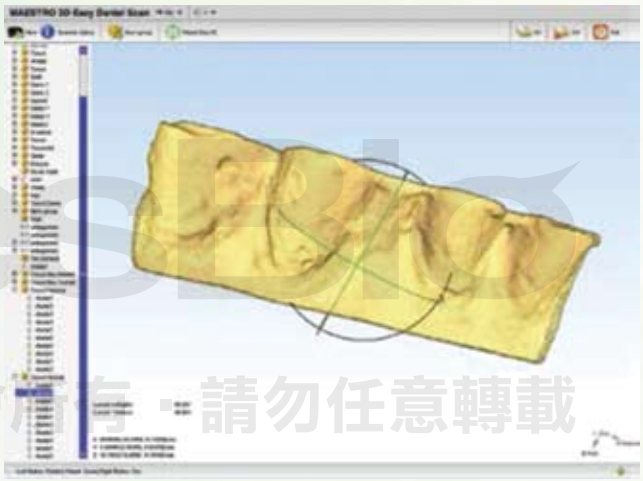

Figure 6: Scanned sample of control group

Results

用一般影像與視野來檢測每顆牙齒的頰側上端環部片狀骨切手術在兩個群組 (Table 1)。

一般視線中，兩個方法當有相類似的影響在骨頭表面型態。

摘要一般三角與點之間的線形的演算法給兩個群組 in Table 2。

微觀上，沒有明顯的關係價值在一般三角與點之間的線形的演化法 (rcurrent triangles = 0.0207; rcurrent vertices = 0.0289)。但有正向關係在一般三角與點之間的線形的演算法之間如點陣數據化的確認 (rtest = 0.9999; rcontrol = 0.9999)。

測試組在一般三角與點之間的線形的演算法的數據至少三倍大於控制組 (Table 3)。在臨床上，粗糙骨頭表面不會影響到牙冠增長術的結論，因為必要的因素是 crevicular bone 的形狀，與維持生物寬度。

Table 1: Collar Osteotomy Presence		
sample #	test	control
1	+	+
2	+	+
3	+	+
4	+	+
5	+	+
6	+	+
7	+	+
8	+	+
9	+	+
10	+	+

Table 2: Triangles and Vertices in Test and Control Groups				
	Test Group – Er:YAG Laser		Control Group – Bur	
sample #	current triangles$_{laser}$	current vertices$_{laser}$	current triangles$_{rotary}$	current vertices$_{rotary}$
1	237817	119268	88321	44442
2	357844	179509	99327	49954
3	360003	180600	92324	46556
4	365576	183417	105184	52938
5	256177	128619	104786	52676
6	356506	178801	99866	50246
7	331478	166277	90831	45753
8	331606	166454	109813	55266
9	374712	188024	103997	52364
10	377480	189329	81639	41204

Table 3: Surface Roughness Values in Test and Control Groups				
	Test Group – Er:YAG Laser		Control Group – Bur	
	current triangles$_{laser}$	current vertices$_{laser}$	current triangles$_{rotary}$	current vertices$_{rotary}$
minimum	237817	119268	81639	41204
maximum	377480	189329	109813	55266
median	357175	179155	99596.5	50100
average	334919.9	168029.8	97608.8	49139.9

Discussion

儘管牙冠增長術可預測的美觀結論，調整牙齦外露是有效果的，傳統手術技術的癒合時間是延遲的，這是缺點。想達到縮短癒合時間要使用不同的工具如骨刀，和鉺雅克雷射。骨刀比旋轉器械傷口較少。然而，一些器具，仍然需要提供翻瓣去實施牙冠增長術。

翻瓣延長癒合時間。只要骨膜從皮質骨分離，宿主發炎反應被刺激且開始反應。皮質骨血液被打斷，就有可能外側皮質骨開始吸收。翻瓣手術伴隨著痛，水腫與發炎反應。一言以敝之，不翻瓣就可避免這些問題。

牙科硬組織雷射已經被發現較少傷口比較於其他手術裝置，牙科雷射經常使用於牙冠增長術在過去20個年頭。技術在不翻瓣的牙冠增長術中，促進傷口術後舒適，順利的傷口癒合是可見的。適合的 quartz or sapphire delivery tips of erbium lasers 可以放入牙周囊袋直到皮質骨；沿靠著 laser tip，去皮質骨是可以到想要的位置。

千萬小心，放入 laser tips，請平行牙根表面，避免造成 cementum 剝離。將 laser tips 垂直地，一節一節地放入囊袋，直到結締組織。剝離作用發生在根尖方向，感覺親觸反應，透過 the laser handpiece 從硬組織到 the tip. 重覆深入手術區，環繞牙體周圍，使軟硬組織剝離透過 laser-assisted thermo-mechanical ablation mechanism，沒有翻瓣中進行。有可能一些不怎麼規則的骨頭表面被 erbium laser 造成，但可以使用 Gracey curettes 使表面平滑些。

在手術介入後，點陣化應該被備註。點陣化步驟的結晰度是要高度，微孔隙的。再由使用 curette 之後，被剝離遺留下的硬組織中創造出來。Gracey curettes 大部分被使用於確定骨頭不規則的移除在牙周囊袋間的剝離作用。Diamond bur 常被使用來移除上端環部骨頭，要注意的是，減少與牙根表面的接觸. 使用 Diamond bur，不想要的一條溝有可能出現在牙根表面，事後還是要用牙根刮除術移除，或者減少。在視野中，不規則的骨表面還是看得到，但是沒有深的“溝”或著尖尖地碎片。

Conclusion

此研究的結論，使用活的動物組織，提供支持且建議無裂隙手術呈現於 Er:YAG lasers，且使骨脊在朔型如傳統手術一般。此次實驗研究考慮的只有骨頭上的實際變化，並不是可能是臨床上雷射在軟硬組織上的後繼效應。然而，此實驗可以被嚴格討論，但不包括被長期研究.為了此一目的，研究團隊已經延伸至活體。另一方面，在一些臨床期刊，不翻瓣的骨性牙冠增長術在過去十年，成功率相當高。所以，當一發現不翻瓣手術的優點，雷射輔助步驟將被考慮，或者建議採取的一項技術，與傳統牙冠增長術相較之下。

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