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Hard and soft tissue profile changes following anterior subapical osteotomy in bimaxillary dentoalveolar protrusion patients

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The purpose of this study is to evaluate hard and soft tissue changes following the first four premolar extractions and anterior subapical osteotomy in bimaxillary dentoalveolar protrusion patients requiring maximal retraction of anterior segments. A sample of 20 adult female patients was selected. Surgical procedures were performed by the same surgeon, and modified segmental osteotomy and anterior subapical osteotomy techniques were employed on the maxilla and mandible respectively. Pre-surgical and post-surgical lateral cephalometric radiograms were traced and superimposed using the best-fit method and two reference planes.

The results were as follows

1. The bodily movement of the maxillary anterior segment was achieved in a posterior direction. The mandibular anterior segment was moved posteriorly with a slight correction of the lower incisors.
2. The horizontal soft tissue measurements changed significantly after treatment, but Nt and Sn landmarks remained unchanged. The vertical soft tissue measurements indicated that Ls moved inferiorly and Li superiorly.
3. The correlation between hard and soft tissue changes indicated that ⊿HId/ ⊿HLi, ⊿HId/ ⊿LL-Eline, ⊿HPt.B/ ⊿HILS, and ⊿UI-FH/ ⊿NL were significant.
4. More lower lip relative to upper lip retraction was demonstrated in relation to Rickett's E-line. The ratio between upper incisor and upper lip displacement was 50%, and between the lower incisor and lower lip displacement was 60%.

We conclude from the results that the anterior subapical osteotomy is an efficient treatment option for adult patients who have severe dentoalveolar protrusion and desire rapid results.

Key words : Anterior subapical osteotomy, Bimaxillary Protrusion, Profile change

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People are becoming more interested in esthetics and more motivated to improve their facial appearance. Nose-lip-chin relationships play a very important role in the determination of facial esthetics.[1]

Lip and dental protrusions are some of the most common complaints other than crowding, especially in East Asians. Typical orthodontic treatment for patients who exhibit excessive flaring of maxillary and mandibular incisors and resultant lip fullness, is extraction of the first four premolars followed by retraction of anterior teeth. However, the degree of success in treatment outcome is determined by several factors, such as adequate consideration of anchorage requirements, adequate patient compliance with the extraoral traction devices, use of efficient biomechanics, and the patient's facial skeletal pattern.[2]

When these contributing factors are adequately managed, it is possible to obtain excellent esthetic results with bimaxillary dentoalveolar protrusion patients by orthodontic treatment alone. However, treating adult patients may be more complicated. It is more difficult to achieve physiologic tooth movement in adults than in children and adolescents, and thus treatment time tends to take longer. Long treatment time required in adult treatment creates tremendous stress both for patients and orthodontists. Also periodontal problems often lead to compromised treatment results. Considering these inherent limiting factors, extraction of premolars and surgical retraction of anterior segments utilizing the subapical osteotomy technique may be considered as a good alternative treatment method.[2,3]

Since anterior segmental maxillary osteotomy was first introduced by Cohn-Stock[4] in 1921, it has become increasingly popular and has been modified and improved. There are three techniques that are most commonly used: the Wassmund method,[5] the Wunderer method,[6] and the Bell downfracture technique.[7,8] Ahmed[9] reported very positive findings regarding the long-term stability of the results derived from this technique, and a satisfactory esthetic and occlusal outcome with minimal post-operative complications. However, potential complications, such as devascularization and devitalization of the repositioned segment, the possibility of profuse bleeding, and excessive tipping of the segments, prohibit surgeons from using this technique in everyday practice.[2,10] This is apparent from the fact that there are very few well-documented reports analyzing changes that occur between pre-surgery and post-surgery.

It is a well-known fact that osteotomies used to correct deformities and anomalies of the maxillo-mandibular complex also produce changes in the shape and position of the soft tissue. However, it is difficult to predict to what extent and in what direction these soft tissues changes will occur. An earlier study by Lines and Steinhauser[11] found ratios in hard and soft tissue profile changes to be 50% for upper incisor and lip displacement, and 75% for lower ones. However, different ratios were reported by Lew.[12] Values of 43% and 71% were found for the upper and lower ratios respectively. Yet another study by Park[13] demonstrated values of 90% for the upper ratio and 99% for the lower ratio.

The purpose of this study is to measure the hard and soft tissue profile changes, and to establish the ratio between the incisor and lip displacement following the first four premolar extractions and anterior subapical osteotomy in bimaxillary dentoalveolar protrusion patients requiring maximal retraction of the anterior segments.

MATERIALS AND METHODS

One of the authors (T.H. Yoon) provided records of patients who had four premolars extracted and anterior subapical osteotomy surgery. Among the more than 150 patients who were treated with this treatment protocol for profile reduction, twenty patients were included who met the selection criteria established in this study. The criteria included: Korean patients with a skeletal class I malocclusion, bimaxillary dentoalveolar protrusion patients who desired and accepted maximal retraction of anterior teeth via the extraction of the first four premolars, and the availability of an acceptable quality pre-surgical and post-surgical lateral cephalograms. All patients were female and mean age was 30 years and 7 months (Mean ± S.D.: 30.53±7.04 yrs/ Range: 21.50-44.17 yrs).

Post-surgical records were taken between 3 and 4 weeks from the day of the surgery. Surgical procedures were performed by the same surgeon, and modified segmental osteotomy and anterior subapical osteotomy techniques were employed on maxilla and mandible respectively. Since most patients presented acceptable posterior occlusion, no orthodontic treatment was done prior to surgery. A prefabricated surgical splint was utilized to assist with the accurate fixation of the mobilized segments and was removed after surgery. Pre-surgical and post-surgical lateral cephalograms of each patient were traced and superimposed by one orthodontist. The Frankfort horizontal (FH) plane and the Nasion vertical plane (which is perpendicular to the FH plane) were constructed for measurements (Fig.1). These reference planes were transferred from the pre-surgical cephalogram to the post-surgical cephalogram for accurate superimposition and measurement. In order to describe hard and soft tissue changes following the surgery, the landmarks presented in Fig.1 were measured in relation to the reference planes.

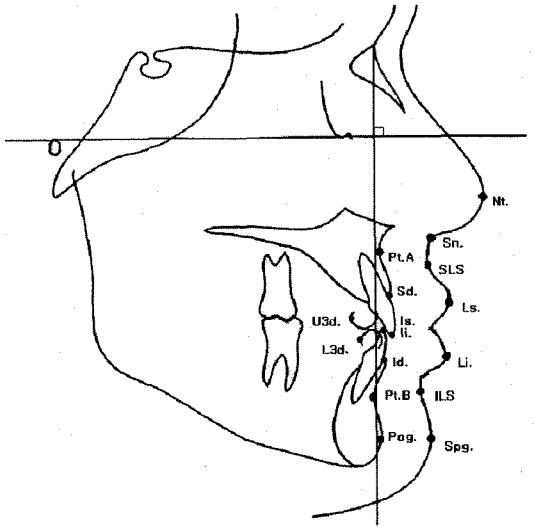

Fig. 1. Reference planes and landmarks used in lateral aspect

<Linear measurements>

1) Landmarks of hard tissue measurements

1. Pt.A (Subspinale): point of greatest concavity on the anterior border of the maxilla
2. Sd (Supradentale): the most anterior inferior point on the premaxillary alveolar process, usually found near the cemento-enamel junction of the maxillary central incisors
3. Is (Incisor superius): the incisal tip of the most anterior maxillary incisor
4. U3d (Distal contact point of upper canine)
5. Ii (Incisor inferius): the incisal tip of the most anterior mandibular incisor
6. Id (Infradentale): the most anterior superior point on the mandibular alveolar process, usually found near the cemento-enamel junction of the mandibular central incisors
7. L3d (Distal contact point of lower canine)
8. Pt.B (Supramentale): point of greatest concavity on the anterior border of the symphysis
9. Pog (Pogonion): the most anterior point on the contour of the symphysis

2) Landmarks of soft tissue measurements

1. Nt (Nose tip): the most prominent point in the mid-sagittal plane of the nose
2. Sn (Subnasale): the point at which the nasal septum merges with the upper cutaneous lip in the mid-sagittal plane
3. SLS (Superior labial sulcus): the deepest point between the subnasale and the labrale superius in the midsagittal plane
4. Ls (Labrale superius): the point indicating the muco-cutaneous border of the upper lip
5. Li (Labrale inferius): a point indicating the muco-cutaneous border of the lower lip
6. ILS (Inferior labial sulcus): the deepest point between the lower lip and chin in the midsagittal plane
7. Spog (Soft tissue pogonion): the most anterior point on the chin
8. UL-Eline (Upper lip to E-line): The distance from the upper lip to the E-line
9. LL-Eline (Lower lip to E-line): The distance from the lower lip to the E-line

Table 1. Hard tissue changes between pre-surgery & post-surgery

	Before(T1)		After(T2)		T1-T2		
	Mean	SD	Mean	SD	Mean	SD	Sig.
Horizontal(mm)							
PointA	4.600	3.831	-1.35	3.941	5.950	1.432	0.000***
Sd	11.200	4.808	5.175	4.772	6.025	1.094	0.000***
Is	14.125	5.112	7.925	5.043	6.200	1.418	0.000***
U3d	-2.050	4.591	-8.175	4.601	6.125	1.307	0.000***
Ii	10.575	4.598	3.375	4.907	7.200	1.371	0.000***
Id	7.725	5.270	1.100	5.814	6.625	1.404	0.000***
L3d	-0.850	4.626	-7.600	5.180	6.750	1.362	0.000***
PointB	-0.800	6.424	-6.925	6.685	6.125	1.404	0.000***
Pogonion	-1.775	7.392	-2.200	7.266	0.425	1.794	0.303
Vertical(mm)							
PointA	34.000	2.555	33.000	2.565	1.000	1.158	0.001***
Sd	47.050	2.509	46.225	2.478	0.825	1.372	0.009***
Is	60.425	2.632	59.375	2.832	1.050	1.385	0.003***
U3d	54.735	2.256	53.650	2.606	1.075	1.115	0.000***
Ii	58.175	2.944	57.075	2.687	1.100	1.154	0.000***
Id	66.975	2.707	65.875	2.738	1.100	1.083	0.000***
L3d	60.175	2.546	59.500	2.796	0.675	1.217	0.023*
PointB	78.350	2.992	77.250	3.271	1.100	1.324	0.001***
Pogonion	94.050	3.759	93.925	4.159	0.125	0.825	0.506
Angular( )							
UI-FH	120.900	5.614	119.575	6.658	1.325	3.250	0.084
LI-MP	102.525	8.263	99.850	7.972	2.675	2.386	0.000***

*p<0.05, **p<0.01, ***p<0.001

<Angular measurements>

1) Hard tissue measurements

1. UI-FH (Upper central incisor to FH): Defined as the angle formed by the FH plane and a line drawn through the long axis of the maxillary central incisor
2. LI-MP (Lower central incisor to MP): Defined as the angle formed by the mandibular plane and a line drawn through the long axis of the mandibular central incisor

2) Soft tissue measurements

1. NL (nasolabial angle): the angle formed by two lines intersecting at the subnasale, one tangent to the lower border of the nose and one passing through the labrale superius
2. ML (mentolabial angle): the angle formed by two lines intersecting at the inferior labial sulcus, one tangent to the soft-tissue chin and one passing through the most anterior inferior point on the lower lip

<Correlation analysis between hard and soft tissue change>

1) ⊿H-: Changes in horizontal measurements between

Table 2. Soft tissue changes between pre-surgery & post-surgery

Measurement	Before(T1)		After(T2)		T1-T2		
	Mean	SD	Mean	SD	Mean	SD	Sig.
Horizontal(mm)							
Nt	31.572	2.912	31.700	2.793	-0.125	0.559	0.330
Sn	17.900	3.841	17.925	3.592	-0.025	1.032	0.915
SLS	19.950	4.221	18.475	4.015	1.475	1.153	0.000***
Ls	25.750	4.555	22.600	4.573	3.150	1.329	0.000***
Li	17.825	5.912	14.125	6.236	4.400	1.667	0.000***
ILS	11.600	6.198	9.075	7.608	2.525	1.930	0.000***
Spog	11.925	7.608	13.350	7.452	-1.425	1.498	0.000***
UL to E-line	2.150	2.091	-0.675	1.541	2.825	1.173	0.000***
LL to E-line	4.750	1.923	-0.175	1.711	4.925	2.129	0.000***
Vertical(mm)							
Nt	19.525	3.962	19.075	3.707	0.450	1.413	0.171
Sn	31.550	2.964	31.550	2.857	0.000	0.874	1.000
SLS	39.850	2.857	39.975	3.118	-0.125	1.223	0.653
Ls	47.425	3.690	48.725	3.654	-1.300	1.332	0.000***
Li	71.075	3.373	69.000	2.938	2.075	1.779	0.000***
ILS	76.775	3.420	76.375	3.004	0.400	1.744	0.318
Spog	92.625	3.677	93.375	3.973	-0.750	2.618	0.216
Angular(°)							
Nasolabial angle	88.550	8.522	101.850	7.952	-13.300	3.176	0.000***
Mentolabial angle	132.875	9.067	137.725	5.961	-4.850	9.627	0.036*

*p<0.05, **p<0.01, ***p<0.001

pre-surgery & post-surgery

2) ⊿V-: Changes in vertical measurements between pre-surgery & post-surgery

For statistical analysis, descriptive statistics (mean, standard deviation, and ranges) were calculated for each of the cephalometric measurements at T1 and T2 (Table 1 & Table 2). The data was analyzed with a commercial statistical package (SPSS for Win 8.0 Version). Independent-sample T-tests were used to analyze differences between the paired pre-surgical and post-surgical cephalometric variables. Spearman correlation analysis was used to analyze correlation between hard and soft tissue changes.

RESULTS

The descriptive statistics (including mean and standard deviation), p-values for observations at T1, T2, and changes that occurred following the surgery are shown in a horizontal dimension and indicate statistically significant changes. Similarly, there were statistically significant vertical changes in superior direction in all the hard tissue variables. There were no

Table 3-1. Correlation coefficient (r) for comparison of hard and soft tissue changes (Spearman correlation analysis)

	⊿HSLS	⊿HLs	⊿HLi	⊿HILS	⊿HSpg	⊿NL	⊿ML	⊿UL-Eline	⊿LL-Eline	⊿VLs	⊿VLi
HPt.A	.008	.064				.092		.118		.029	
HSd	.094	.253				-.17		.285		.165	
HIs	.158	.404*	.361			-.544*		.363	.428	.27	.012
HU3d	.233	.457*				-.411		.407		.026	
HIi	-.122	.009	.543*	.467*	.126		.115		.535*		-.082
HId			.582**	.531*	.109		.118		.596**		-.056
HL3d			.44	.367	.155		.101		.392		-.021
HPt.B			.442	.527**	.285		.272		.305		-.054
UI-FH	.213	.403	-.269			-.653**		.282		.061	
LI-MP			-.301	-.322	.012		-.122		-.026		-.137

*p<0.05, **p<0.01, ***p<0.001

Table 3-2. Correlation coefficient (r) for comparison of hard and soft tissue changes (Spearman correlation analysis)

	VLs	VLi	NL	ML	HLs	HLi	HILS
VPt.A	.338		-.214		-.017	-.014	-.132
VSd	.242		-.204		-.139	-.123	-.28
VIs	.418		-.384		.046	-.031	-.08
VU3d	.395				-.242	.056	-.043
VIi		.443		-.238	259	-.006	-.257
VId		.502*		-.149	.269	-.021	-.139
VL3d		.493*		-.219	.301	.197	-.048
VPt.B		.496		-.18	.207	.049	-.111

*p<0.05, **p<0.01, ***p<0.001

significant upper incisor angulation changes, although lower incisor angulation decreased significantly.

Measurements of soft tissue profile changes in the horizontal dimension showed that the position of Nt and Sn remained unchanged, but SLS, Ls, Li and ILS moved posteriorly while SPog anteriorly. The soft tissue measurements in the vertical dimension showed that the position of Nt, Sn, SLS, ILS and Spog remained unchanged, but Ls and Li changed significantly. The Nasolabial angle showed a significant increase (13.3° ± 3.17°). As for the changes of lip position, the mean reduction of upper and lower lip protrusion to Rickett's E-line were 2.83 and 4.93 mm respectively. These changes are statistically significant.

The correlations between hard and soft tissue changes were shown : ⊿HId/⊿HLi, ⊿HId/ ⊿LL-Eline, ⊿HPt. B/⊿HILS, and ⊿UI-FH/⊿NL showed significant correlations (p<0.01) (Table 3-1 & 3-2).

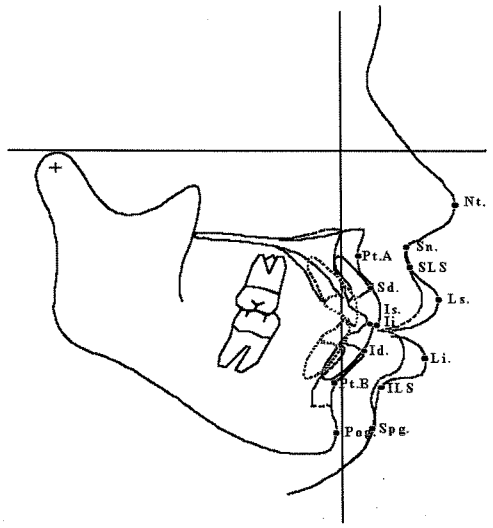

Fig. 2. Superimposition of hard and soft tissue landmarks before(T1)and after(T2) treatment. <Solid line(T1), dotted line(T2)>

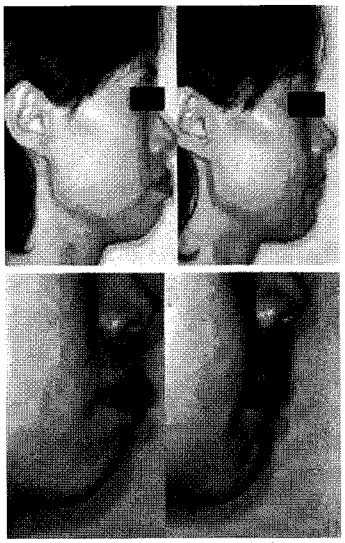

Fig. 3. Typical profile changes following anterior subapical osteotomy

DISCUSSION

Anterior subapical osteotomy has been performed to correct various types of dentoalveolar deformities. Severe facial convexity and bimaxillary protrusion frequently occur in Asian populations. Yokoo et al[14] have suggested that osteotomy is indicated mainly in cases where tooth repositioning by orthodontic treatment is limited, where social conditions (eg. age, time, finances) preclude orthodontic treatment, or where revision of orthodontic or surgical treatment is required. It is obvious that the segmental osteotomy technique could offer many benefits that typical orthodontics alone cannot offer in treating bimaxillary protrusion patients. However, it takes great surgical skills and experience to overcome the potential risks and complications of this technique.

Although there are many articles written on the description and modification of the surgical technique itself, these are relatively few studies with adequate data examining the changes after the surgery. Thus most orthodontists do not know enough about hard and soft tissue changes resulting from anterior subapical segmental surgery.

Samples were obtained from an orthodontist and a surgeon who experienced in using this combined surgical-orthodontic treatment protocol. After reviewing over 150 cases who had bimaxillary anterior subapical osteotomies, patients requiring four first premolar extraction and maximal retraction of anterior segments were selected for the analysis of homogeneous group of sample. Typical pre-surgical and post-surgical facial profile changes are shown in Fig. 2 & 3.

This study was conducted to report cephalometric data for better understanding of the hard tissue changes and the associated tissue profile changes. Cephalometric analysis of hard tissue changes revealed that the maxillary anterior segments was moved posteriorly in a bodily movement and the mandibular anterior segment was moved posteriorly with a slight uprighting of the lower incisors. This suggests that when the subapical osteotomy is performed properly by a skillful surgeon, the anterior segment could be retracted without excessive tipping.

The mean displacement of U3 was 6.1 mm (S.D. =1.3) and of L3 was 6.7 mm (S.D.=1.3). This implies that nearly maximal retraction of anterior segments was achieved with this surgical technique. Changes in all the

hard tissue vertical measurements were statistically significant. However, mean value of 1.0 mm movement in a superior direction at the incisor tip may not be of a clinically significant value. The mean reduction of upper and lower lip protrusion were 3.2 and 4.4 mm respectively, in relation to the reference planes. However, it should be remembered that the post-surgical records were obtained within 1 month from the day of surgery. Thus post-surgical swelling may still have not been fully subsided. The relative changes of upper and lower lip position to Ricketts' E-line were 2.8 and 4.9 mm respectively. According to Ricketts' measurement, more retraction of the lower lip was demonstrated relative to upper lip change 1 month after the surgery. The difference between the two methods of evaluating lip position change is due to the positional change of soft tissue Pogonion. Findings indicated that SPog moved anteriorly. This is explained by the residual soft tissue swelling followed by the surgery. The ratio between the upper incisor and upper lip displacement was 50% and that between the lower incisor and lower lip displacement was 60%. This data conforms with Wolford's prediction.[15]

Lu et al[16] indicated that the lower lip was found to be the least accurate portion for prediction. This source of in accuracy could be explained by several causes: the lower lip is pliable and subject to the influence of incisor position and angulation, soft tissue thickness and tonicity, perioral musculature, and underlying muscle attachments.

Further studies are required to evaluate definite soft tissue changes at least 6 months after the day of surgery. Long term follow-up is also necessary to evaluate hard tissue stability, because the results obtained from this study are only a description of immediate post-surgical changes that occured within a relatively short period.

CONCLUSIONS AND SUMMARY

The purpose of this study was to evaluate hard tissue and soft tissue changes following four first premolar extractions and anterior subapical osteotomy in bimaxillary dentoalveolar protrusion patients requiring maximal retraction of anterior segments. A sample of 20 adult female patients was selected. Pre -surgical and post surgical lateral cephalometric radiograms were traced and superimposed using best fit method and two reference planes.

The results were as follows:

1. The maxillary anterior segment was moved posteriorly in a bodily movement and the mandibular anterior segment was moved posteriorly with a slight correctroll of lower incisors.
2. The horizontal soft tissue measurements changed significantly after treatment, but Nt and Sn landmarks remained unchanged. The vertical soft tissue measurements indicated that Ls moved inferiorly and Li superiorly.
3. The correlation between hard and soft tissue changes indicated that ⊿HId/⊿HLi, ⊿HId/⊿LL-Eline, ⊿HPt.B/⊿HILS, and ⊿UI-FH/⊿NL were significant.
4. More lower lip relative to upper lip retraction was demonstrated in relation to Ricketts' E-line. The ratio between the upper incisor and upper lip displacement was 50% and that between the lower incisor and lower lip displacement was 60%.

We conclude from the results that anterior subapical osteotomy is an efficient treatment option for adult patients who have severe dentoalveolar protrusion and desire a rapid outcome.

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국문초록

양악성 치조 전돌 환자의 근첨하 분절 골절단술 후 경조직 및 연조직 측모 변화

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본 연구는 입술 및 치아 돌출을 주소로 내원한 교정 환자를 소구치 발치와 근첨하 분절 골절단술로 전치부의 최대 후방 이동을 도모한 증례들에서 이로 인한 수술 전후의 측모 변화를 알아보고자 시행하였다. 양악 전돌증을 동반한 골격성 제 I 급 부정 교합 환자 20 명의 수술 전과 후 측모 두부X-선 사진을 중첩하여 경조직 및 연조직의 변화를 평가하여 다음과 같은 결론을 얻었다.

1. 상악 전치부는 후방으로 치체 이동하였고, 하악 전치부는 후방으로 약간의 경사 이동하였다.
2. 수평 방향의 연조직 변화는 Nt와 Sn를 제외하고는 모든 항목이 유의성 있 게 변화하였고, 수직 방향으로는 Ls는 하방으로, Li는 상방으로 유의성 있 게 변화하였다.
3. 경조직변화에 대한 연조직변화의 상관 관계는 ⊿HId/⊿HLi, ⊿HId/⊿LL-Eline, ⊿HPt.B/⊿HILS 와 ⊿UI-FH/⊿NL에서 높게 나타났다.
4. Ricketts' E-line에 대해 상순변화에 비해 하순의 더 많은 후방 이동을 보였다. 상악 전치 변위에 대한 상순 변위 비율은 50%였고, 하악 전치 변위에 대한 하순 변위 비율은 60%였다.

위에서 언급된 결과로서, 근첨하 분절 골절단술은 심한 치조 전돌 환자에게 효율적인 치료법으로서 빠른 외모 개선의 결과를 가져오는 수술적 접근 방법이다.

주요 단어 : 근첨하 분절골 절단술, 양악성 치조 전돌, 외형 변화