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Buccal corridor changes in orthodontically treated extraction and non-extraction Class 1 patients

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ABSTRACT

BACKGROUND
Patients seek orthodontic treatment mainly to improve their facial aesthetics and obtain an acceptable smile. It is purported that orthodontic extraction treatment may result in narrow buccal corridors which in turn may lead to unaesthetic smile.

AIM
To determine if the dimensions of the buccal corridors are influenced by extraction or non-extraction treatment in Class 1 patients.

DESIGN
Retrospective record-based study conducted between 2012 and 2017 at University of Pretoria Orthodontic department.

MATERIALS AND METHOD
Smile pictures of pre- and post-treatment Class 1 patients treated with or without premolar extractions were matched. Buccal corridors between the two groups were measured by measurement of visible maxillary dentition and oral aperture dimensions. Data analysis included frequencies and correlations using chi-square test, with a significance level set at $p<0.05$.

RESULTS
Seventy-one patient records met the selection criteria with the majority being females (70%). The age range was between 10 and 37 with a mean of 17.5 years. Thirty-five patients were treated with extractions and thirty-six patients with non-extraction treatment. There was a significant difference in the visible maxillary dentition pre and post treatment with extraction patients showing a 6 to 6 and non-extraction showing 5 to 5 dentition post treatment ($p<0.05$). There were no differences in the ratios of the visible maxillary dentition and oral aperture in both groups pre and post treatment ($p> 0.05$).

CONCLUSION
Orthodontic treatment of Class 1 cases with premolar extraction did not lead to deleterious changes in the buccal corridors.

Keywords: Buccal corridors changes, extraction, non-extraction, visible maxillary dentition, oral aperture

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INTRODUCTION
Patients increasingly seek orthodontic treatment to improve their aesthetics and create a beautiful smile. Goldstein stated that second to the eyes, a smile rates as the most important feature of facial attractiveness.[1] Patients with different personality traits ranging from very shy to very confident, introverts to extroverts, prioritized an attractive smile at the top of their list with regards to their aesthetic requirements. The amount of teeth that show when an individual smile as well as other characteristics such as the buccal corridors are deemed important.[2]

The term "buccal corridor" was added to the dental terminology list by specialists in the discipline of prosthodontics in the late 1950's who described it as the space revealed between buccal surfaces of posterior teeth and commissures of the lips when the patient is smiling.[3, 4] When arranging teeth of removable prostheses, clinicians aimed to recreate a natural appearance by incorporating the buccal corridors. In an ideal smile, bilateral buccal corridors should be evident separating the teeth from the commissures of the mouth. This space is said to be altered by transverse narrowing of the maxilla, palatal inclination of the posterior maxillary teeth, the degree of smile arch, vertical facial pattern, antero-posterior positioning of the maxilla, and extraction and non-extraction orthodontic treatment[3]. The influence of the buccal corridor on smile aesthetics has been described by some researchers as having no influence,[5, 6] while other investigators believe that the absence of buccal corridors gives the patient an unnatural "denture" appearance.[7] On the other hand, prosthodontists aim to recreate a natural dental presentation when setting denture teeth and deemed a molar-to-molar smile (which eliminated the buccal corridors) a characteristic of a poorly

constructed denture.[7] It has been postulated that the eye is able to detect subtle variations in a smile, even when those variations are seen in the context of the entire face. The presence of broad smile fullness (minimal buccal corridors) was consistently judged by lay persons to be more attractive than narrower smile fullness (larger buccal corridors). Observational studies looking at the acceptability threshold for the size of the buccal corridor across different ethnic groups have also been carried out. The threshold is measured as a percentage measure of the visible maxillary dentition width against the oral aperture width. Results revealed that thresholds from as little as 10% to as much as 40% were deemed acceptable aesthetically.[8]

The Inclination of teeth is one of the six keys described by Lawrence Andrews in 1927 to be important in occlusion.[9] Inclination of the canines, the first premolars and the second premolars have an impact on the size of the buccal corridors and the attractiveness of the smile. When treating patients with a skeletal transverse discrepancy, a trade-off may be necessitated between occlusal function and smile aesthetic. This is due to the fact that varying the bucco-lingual inclination of teeth could affect both the functional occlusal contact and the attractiveness of the smile.[10]

Normal values proposed by Andrew for canines, first premolars and second premolars were -7°, -7° and -7° respectively. Laypersons observing the effect of bucco-lingual inclinations of maxillary canines and premolars on perceived smile attractiveness, preferred frontal smiles with the canines and premolars positioned at inclinations varying from 3° to 10° whereas orthodontists preferred smiles showing canine inclination of 0° - 10° and -3° to -11° for premolars. Within this range, changes in inclination were considered not immediately likely to affect smile aesthetically.[10]

Features that have been postulated to impact the size of the buccal corridors include: arch form and size, degree of smile arch, antero-posterior position of the maxilla in relation to the mandible, transverse dimension of the maxilla and the extraction of premolars.[11] Some authors are of the opinion that extraction treatment results in narrower dental arches which, in turn, are associated with a less aesthetic smile on account of the dentition being less full during a smile.[12] In addition, this arch width reduction creates unaesthetic spaces lateral to the buccal segments. In a study done to compare arch width changes and smile aesthetics in patients treated with and without extractions, it was concluded that constricted arch widths were not a usual outcome of extraction treatment.[13] Another finding of this study was that neither extraction nor non-extraction treatment had a preferential effect on smile aesthetics. The mean aesthetic score between the extraction and non-extraction groups were the same. Most subjects displayed ten teeth, second largest group displayed eight teeth (33 percent) and the least group displayed twelve teeth (17 percent), and all these were equally distributed between the extraction and non-extraction group.[13]

An average smile in untreated individuals displays teeth from incisors to premolars and the aesthetic value of such a smile was reviewed by Dong and colleagues in prosthodontic patients where they found that most patients (57%) displayed teeth up to the second premolar. The subjects who displayed teeth up to the second premolar had the highest aesthetic score of all the groups.[14] In extraction treatment the closure of extraction spaces often results in mesial movement of premolars and molars to a narrower part of the arch. The latter implies that the depth (antero-posterior dimension) of the dentition decreases in extraction treatment and leads to premolars and molars emerging into the displayed smile. The anterior segments of both arches (maxilla and mandible) represented by the inter-canine widths remain the same before and after treatment in both extraction and non-extraction groups.[15]

In previous studies done that have focused on the aesthetic rating of the buccal corridor, it has been highlighted that patients prefer to have some degree of the buccal corridor evident.[16] This factor may have an impact on the choice of treatment when considering whether to extract teeth or not. Generally, both patients and orthodontists find smiles with small and medium sized buccal corridors (0-10%) more aesthetic than those with large buccal corridors,[16, 17] with minor asymmetry in size of the corridors not having much effect on their aesthetic rating. This study aimed to investigate how the buccal corridors are affected by the extraction protocol versus non-extraction protocol in skeletal Class I patients. The results of this study may be a helpful tool in deciding which treatment protocol to follow to improve the final aesthetic result.

MATERIALS AND METHODS

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Health Sciences, University of Pretoria (Ref: 51/2018). No personal details of the patients were disclosed, and all information was strictly confidential and anonymous. A retrospective record-based study with data extracted from patients treated in the Department of Orthodontics at University of Pretoria was conducted. The study evaluated pre-treatment and post-treatment photographs of extraction and non-extraction patients of Class I patients. All subjects had been treated with maxillary and mandibular contemporary fixed appliances, with the aim in each case to provide an ideal interdigitating occlusion as suggested by Lawrence Andrews.[8] Instructions given to the patients upon taking the photos were to give “a natural and unstrained smile showing teeth”. Smile photos were taken in the same clinical ward against a white background using a Canon EOS 1200D camera with a macro lens (or equivalent) and a ring flash light.

Class 1 patients under the age of 40 years who were treated with fixed comprehensive orthodontic appliance were drawn from a list in the Dolphin tracing program used by the department of Orthodontics for patients treated between 2012 to 2017. Patients older than 40 years of age, or treated with functional appliances and who were Class 11 and 111 were excluded from the study. Measurements of the oral aperture were made from the labial commissure of one side to the other and of the visible maxillary dentition from the last visible tooth on the one side to the other. These measurements were represented as a percentage ratio for pre-treatment smile and post treatment smile of each patient. Measurements were made directly on the photographs displayed on the computer screen using a measuring software (Ruler by Maokun software). The method used in this study was initially used in a study by Martin et al., and eliminates the

Figure 1. Illustration of the pre-treatment and post-treatment measurements on frontal smile photographs.

problem of pictures not taken from the same distance away from the patient.[18]

A comparison of the size of buccal corridors between the two groups of patients (extraction patients and non-extraction patients) were then analysed. The measurement of the buccal corridor sizes was represented as a ratio between visible maxillary dentition and oral aperture width:

$$R = \frac{\text{Visible maxillary dentition X 100\%}}{\text{Oral aperture width}}$$

The photographs were selected alphabetically and divided into two groups:

- Group 1 (pre-treatment and post treatment smile photos treated with extractions)
- Group 2 (pre-treatment and post-treatment smile photos treated with non-extractions)

These initial diagnostic pictures were paired with the final pictures at the end of treatment

Data was analysed with SPSS software (version 25; IBM, Somers, NY). Descriptive statistics were calculated for all raw demographic and photographic measurements. Mean pre-treatment and post treatment values and changes (pre-treatment against post-treatment) were calculated for each dependant variable (photographic measurements). The main analyses were based on the change scores (pre-treatment versus post-treatment) as the set of dependent variables and treatment group as the main factor (non-extraction versus extraction) of interest. Chi square test was used to evaluate the association between variables. The level of significance was set at $p< 0.05$. The missing data was omitted during data analysis.

RESULTS

From a total of 871 patient records collected from 2012 to 2017 on the Dolphin program, only seventy-one records were found to meet the inclusion criteria. Most patients were female 50 (70%) and 21 (30%) were male with the ages ranging from 10 to 37 years and a mean of 17.5 years.

Thirty-five (49%) patients were treated with extractions of premolars of which twenty-seven (77%) were females and seven (23%) were males. Of the thirty-five patients treated with extractions twelve of them were older than 18 years. Thirty-six (51%) patients were treated with non-extraction of premolars and the majority were females 23 (64%)) with the rest being males 14(36%). Just over half of the patients were therefore non extraction cases.

The results for extraction cases show that post treatment the smiles showing up to canines only were in the minority with only 3 subjects. Smiles which showed up to the first molars (six to six in Table 1) were more than those showing up to the premolars. This result indicates that there was an addition of visible teeth posteriorly during smiling (Table 1).

In the non-extraction patient's pre-treatment smiles showing teeth up to the first molar were in the minority with 5 patients. The majority of patients had smiles showing up to the second premolars. Smiles showing up to the first premolars decreased from pre-treatment to post-treatment. Smiles displaying up to the second premolars increased from pre-treatment to post-treatment (Table 1).

Table 2 and 3 tabulate the changes in the ratios pre-treatment and post-treatment of the extraction and non-extraction groups respectively. In the extraction group, the results indicate that there was a slight decrease in the

Table 1: Visible dentition change in extraction and non-extraction patients n= 71

		Pre-treatment	Post-treatment
VD Extraction group (n= 35)	Three to three (canine – canine)	5	3
	Four to four (1st prem – 1st prem)	15	6
	Five to five (2nd prem – 2nd prem)	10	10
	Six to six (1st molar – 1st molar)	5	16
VD Non-extraction group (n=36)	Three to three (canine – canine)	5	0
	Four to four (1st prem – 1st prem)	19	13
	Five to five (2nd prem – 2nd prem)	10	18
	Six to six (1st molar – 1st molar)	2	5

Table 2: Comparison of the ratios (Buccal corridor) in the extraction group n=35						
	Smile feature	n	Min	Max	Mean	Std. dev
Pre-treatment Extraction	Oral aperture (mm)	35	3.1	11.0	5.849	1.6283
	Visible maxillary dentition (mm)	35	2.3	10.4	4.685	1.4075
	Ratio	35	52.27%	135.48%	80.2610%	9.85578%
Post-treatment Extraction	Oral aperture (mm)	35	3.0	9.6	5.713	1.4928
	Visible maxillary dentition (mm)	35	2.1	7.7	4.515	1.2627
	Ratio	35	60.38%	92.73%	78.8979%	6.01670%

Table 3: Comparison of the ratios (Buccal corridor) in non-extraction group n= 36						
	Smile feature	n	Min	Max	Mean	Std. dev
Pre-treatment Non-Extraction	Oral aperture (mm)	36	4.1	11	6.12	4.879
	Visible maxillary dentition (mm)	36	2.3	10.4	4.905	5.727
	Ratio	36	52.27	95.92	79.97	30.865
Post-treatment non-Extraction	Oral aperture (mm)	36	3.7	9.6	6.043	4.171
	Visible maxillary dentition (mm)	36	2.8	7.7	4.881	3.464
	Ratio	36	70.59%	92.73%	80.78%	15.655%

Table 4: Association between treatment type and smile width pre- and post-treatment n=71				
		Extraction (n=35)	Non-extraction (n=36)	P-value
Pre-treatment	Three to three	5	5	0.000
	Four to four	15	19	
	Five to five	10	10	
	Six to six	5	2	
Post treatment	Three to three	3	0	0.000
	Four to four	6	13	
	Five to five	10	18	
	Six to six	16	5	

mean ratio (R) which represents a decrease in the buccal corridor size from pre-treatment to post-treatment (Table 2). In the non-extraction group, the mean ratio remained the same from pre-treatment to post-treatment. See Table 3.

There was a statistically significant difference between treatment type and the smile width pre- and post-treatment (Table 4). The extraction group had 15 patients displaying a smile up to the premolars (Four to four). The non-extraction group had 19 patients with a dentition displaying up to the first premolars. This shows a statistically significant difference in the dentition display between extraction and non-extraction groups $p< 0.05$. There were no smiles in the non-extraction group displaying a three-to-three dentition.

There was also a statistically significant difference between dentition display of six-to-six in extraction and non-extraction. Interestingly, there was a statistically significant association found between the treatment type and the smile width post-treatment. Majority of patients treated with non-extraction displayed a smile up to the second premolars. In the extraction group the majority of patients displayed a smile up to the first molars, followed by those with smiles up to the premolars. When an association was made between the buccal corridor of the visible maxillary dentition and the oral aperture in the extraction and non -extraction cases there was found to be no difference $p>0.005$

DISCUSSION

This study's results demonstrated an increase in the number of teeth displayed post-treatment. The number of patients displaying dentition up to first molars in extraction patients were equal to those displaying teeth up to the first premolars. These results correlate with those found by Kim in 2003[11] where they demonstrated subjects displaying ten teeth being the majority group at 50%. They further explained that there was an equal distribution of these types of smiles between extraction and non-extraction groups. Johnston in 1993 investigated the outcomes of premolar extraction in extraction and non-extraction patients on a long-term basis and one of their findings was that in non-extraction treatment, the upper buccal segments were commonly distalized whereas in extraction treatment the upper buccal segments tended to come forward.[16] The results of this study differ to that of Kim because there were more smiles from the non-extraction group displaying dentition up to the second premolar.[11]

Interestingly, this study found no dentitions displaying a canine-to-canine type of smile in the non-extraction group, and only one patient displaying a first premolar to first premolar dentition in the extraction group, and more subjects in the extraction group displaying dentition of up to first molars. This observation could be explained in terms of the type of mechanics employed in closing the extraction spaces in the institution, which is reciprocal space closure which is prone to show dentition up to the first molars as compared to controlled space closure which is more likely to show dentition up to premolars. In light of the mechanics of closing spaces, it can be deduced that the shape of the arch is not necessarily changed by the technique of space closure. Consequently, this implies

that the size of the buccal corridors cannot be altered by extraction or non-extraction treatment as confirmed by Cakan and colleagues.[16]

In this study the buccal corridors represented as a ratio (R) in the extraction group of patients showed a slight decrease from pre-treatment to post-treatment. In the non-extraction group of patients, the mean ratio remained the same from pre-treatment to post-treatment. The results of this study are similar to those found by Meyer and colleagues where they found no significant differences between any pre-treatment and post-treatment measurements of the buccal corridors between the extraction and non-extraction groups.[17]

This study demonstrated an association between treatment type and smile width post-treatment. In patients treated with extractions the majority of patients displayed a smile up to the first permanent maxillary molars, followed by those with a smile up to the premolars. In patients treated with non-extractions the majority displayed a smile up to the second premolars, followed by those with a smile up to first premolars. This study results are similar to those found by Dong and colleagues.[12] Johnson and Smith explained these treatment changes as first molars moving mesially into extraction spaces and emerging into the visible frame of the smile.[18]

There has been a difference in opinion regarding the aesthetic value of buccal corridors. Some hold the opinion that they have no aesthetic value while others believe there is some aesthetic value to buccal corridors.[19] Wylie emphasized that the goal of orthodontic treatment should be to attain the best possible aesthetic result, both facially and dentally.[20] There is the assertion that extraction treatment is inadvertently going to result in constriction of the dental arches, larger buccal corridors and poor aesthetic results.[18] Supporters of non-extraction therapy argue that four premolar extraction results in narrowing of the dental arches with subsequent large and un-aesthetic buccal corridors.[11, 19]

This study aimed to investigate the changes on the buccal corridors effected by orthodontic extraction and non-extraction treatment in skeletal class I patients. The significance of observing this parameter was to investigate if the buccal corridors have an implication on the aesthetic outcome of orthodontic treatment.

CONCLUSIONS

Within the limitations of this study the following can be concluded:

- Most patients were treated with non-extractions, of which the majority were female
- There was a significant increase in the visible maxillary dentition in both extraction and non-extraction groups after treatment
- There were no significant changes in the buccal corridors pre- and post-treatment in extraction and non-extraction patients.
- There was a significant association between the treatment type and the smile width post-treatment.

Limitations of the study

The sample size was not large enough to be able to make more general conclusion results.

There was no record to determine which pattern of extractions was employed in each case in the extraction group. This may shed some light on the type of space closure mechanics used which ultimately would explain the final visible maxillary dentition achieved.

Recommendations

A similar follow-up study including the investigation of the association between extraction patterns and visible maxillary dentition post-treatment on a larger sample is recommended. The study will also have to take into consideration the advances that have taken place with technology which includes advances in photography and cameras and the need for patients to look beautiful like well-known models

REFERENCES

1. Goldstein R. Study of the need for easthetics in dentistry. J Prost Dent. 1969;21(6):589 - 98.
2. Abu Alhaija ESJ, Al-Shamsi NO, Al-Khateeb S. Perceptions of Jordanian laypersons and dental professionals to altered smile aesthetics. Eur J Orthod. 2011;33(4):450-6
3. Sharma PK, Sharma P. Dental Smile Esthetics: The Assessment and Creation of the Ideal Smile. Semin Orthod. 2012;18(3):193-201.
4. Frush JP, Fisher RD. The dynesthetic interpretation of the dentogenic concept. J Prosthet Dent. 1958;8(4):558-8.
5. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod. 1970;57(2):132-44.
6. Roden-Johnson Dustin, Gallerano Ronald, Jeryl E. The effects of buccal corridor spaces and arch form on smile esthetics. Am J Orthod Dentofacial Orthop. 2005;127(3):343-50
7. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 2. smile analysis and treatment strategies. Am J Orthod Dentofacial Orthop. 2003;124(2):116-27.
8. Andrews LF. The six keys to normal occlusion. Am J Orthod Dentofacial Orthop. 1972;62(3):296-309.
9. Xu H, Han X, Wang Y, Shu R, Jing Y, Tian Y, et al. Effect of buccolingual inclinations of maxillary canines and premolars on perceived smile attractiveness. Am J Orthod Dentofacial Orthop. 2015;147(2):182-9.
10. Meyer AH, Woods MG, Manton DJ. Maxillary arch width and buccal corridor changes with orthodontic treatment. Part 2: attractiveness of the frontal facial smile in extraction and nonextraction outcomes. American journal of orthodontics and dentofacial orthopedics : official publication of the AAO, its constituent societies, and the ABO. 2014;145(3):296-30.
11. Kim E, Gianelly AA. Extraction vs Nonextraction-Arch Widths and Smile Esthetics. Angle Orthod. 2003;73(4):354-8.
12. Dong JK, Jin TH, Cho HW, Oh SC. The esthetics of the smile: a review of some recent studies. Int J

Prosthodont. 1999;12(1):9-19.
13. Luppanapornlarp S, Johnston LE Jr. The Effects of Premolar-extraction: A Long-term Comparison of Outcomes in “Clear-cut” Extraction and Non-extraction Class II Patients. The Angle Orthod. 1993;63(4):257-72
14. Nascimento DC, Santos ÊRd, Machado AWL, Bittencourt MAV. Influence of buccal corridor dimension on smile esthetics. Dental Press J Orthod. 2012;17(5):145-50
15. Martin AJ, Buschang PH, Boley JC, Taylor RW, McKinney TW. The impact of buccal corridors on smile attractiveness. Eur J Orthod. 2007;29(5):530-7..
16. Germec-Cakan D, Taner TU, Akan S. Arch-width and perimeter changes in patients with borderline Class I malocclusion treated with extractions or without extractions with air-rotor stripping. Am J Orthod Dentofacial Orthop. 2010;137(6):734-5..
17. Meyer AH, Woods MG, Manton DJ. Maxillary arch width and buccal corridor changes with orthodontic treatment. Part 1: Differences between premolar extraction and nonextraction treatment outcomes. Am J Orthod Dentofacial Orthop. 2014;145(2):207-16
18. Johnson DK, Smith RJ. Smile estheties after orthodontic treatment with and without extraction of four first premolars. Am J Orthod Dentofacial Orthop. 1995;108(2):162-7..
19. Moore T, Southard KA, Casko JS, Qian F, Southard TE. Buccal corridors and smile esthetics. Am J Orthod Dentofacial Orthop. 2005;127(2):208-13.
20. Wylie W. The Mandibular Incisor: Its Role in Facial Aesthetics. Angle Orthod. 1955;25(1) :32-41: 32-41.