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Original Research Article

Comparison of buccal corridor and dental arch width changes in extraction and non-extraction orthodontic treatment

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Abstract: There has been much debate about the effect of extraction and non-extraction treatment on soft tissues and arch width. The aim of this retrospective study was to compare arch and buccal corridor width changes and to evaluate their correlation in extraction and non-extraction orthodontic treatment. Pre-treatment and post-treatment dental models and smile photographs of 59 cases (24 girls and 5 boys in extraction and 20 girls and 10 boys in non-extraction groups) were collected. The intercanine and intermolar widths of maxillary dental arches were measured using a digital caliper. Photographs of samples were evaluated for buccal corridor width in relation to canines and the last visible tooth. The mean intermolar width decreased 0.83 mm in the extraction group and increased 0.13 mm in the non-extraction group. Univarite analysis of covariance showed that post-treatment intermolar width with adjustment of ANB, upper crowding, and pre-treatment intermolar width were different between the two groups (P=0.006). There was a positive correlation only between the buccal corridor width in relation to canines and intercanine width (r value =0.406). Intra-class correlation coefficients for model and photographic variables were from 0.93 to 0.99. There was a significant difference in intermolar width between the two groups, but it did not necessarily result in a difference in buccal corridor width in relation to canines and the last visible tooth between the two groups.
Keywords: Orthodontic treatment, Extraction vs non-extraction, Arch width changes, Smile.

INTRODUCTION

The major goals of orthodontics are function, esthetics and stability. Facial esthetics is associated with profile and smile improvement. Orthodontic treatment can be rendered with or without extraction based on soft tissue characteristics. Patients usually prefer non-extraction treatment. Many advertisements are made on the subject. There has been much debate among orthodontists about the effect of extraction treatment on facial soft tissues and arch width.

One of the smile characteristics is the buccal corridor defined as the space between the buccal surface of the posterior teeth and neighboring soft tissues by focusing on the corners of the mouth [1,2].

Some authors have assumed that treatment via extraction of four premolars results in the development of unaesthetic and larger buccal corridors at the corners of the mouth during smiling [3,4]. Spahl et al reported that extraction of four premolar contracts the dental arch, making the buccal corridor larger [4]. In contrast, another study showed a slightly wider dental arch relative to soft tissues in the extraction group [5]. Johnson and Smith did not find any significant changes in the buccal corridor width during smile in extraction cases [1].

Some authors have made claims about a direct relationship between the arch width and buccal corridor width in smiling [6,7], but there is not sufficient evidence regarding this [8]. On the other hand, there is great variation in the results of previous studies that measured arch width changes in extraction and non-extraction cases. Some studies found that arch width increased after non-extraction treatment [9–11]. Compared to that, in non-extraction treatment, some authors reported that extraction led to a narrower dental arch while others did not achieve this result [4,12].

This variation may be due to differences in treatment modalities, malocclusion type and imprecise measurements. Therefore in this study we tried to achieve a homogenous study group for malocclusion type and treatment mechanics.

Considering the inconsistent results of previous studies and since arch width may affect smile esthetics, the aim of this study was to compare arch and buccal corridor width changes and to evaluate their correlation in extraction and non-extraction procedures.

MATERIALS AND METHODS

Approval was obtained for this study from the Research Ethics Committee of Hamadan University of Medical Sciences. We evaluated pre-treatment and post-treatment dental models and smile photographs of all the patients treated from 2006 to 2014 in the Department of Orthodontics, Faculty of Dentistry, Hamadan University of Medical Sciences. We selected patients based on the following inclusion criteria:

1. Patients treated with the use of maxillary and mandibular fixed appliances.
2. Patients with Class I malocclusion.
3. Patients in the permanent dentition period without any missed permanent teeth or congenitally absent teeth at the beginning of treatment with the exception of the third molars.
4. Patients with no adjunctive expansion appliance such as a Quad Helix or palatal expander used as part of their orthodontic treatment.
5. The extraction group had four premolars extracted with no difference between the first or second premolars
6. Patients with no distalization treatment.
7. Patients without self-ligating brackets.
8. Patients with photographs in naturally posed smile both before and after the treatment.

A total of 59 patients were finally included in the study. The extraction group consisted of 29 (24 girls and 5 boys) and the non-extraction group consisted of 30 (20 girls and 10 boys) patients.

Model analysis

Pre-treatment and post-treatment measurements were carried out on study models using an electronic digital sliding caliper (ABSOLUT; Mitutoyo, Japan) to the nearest 0.01 mm (Fig 1, 2). According to Gianelly, intercanine and intermolar widths were measured in the canine and molar regions from the most labial point of the buccal surfaces. The caliper was placed at the best estimate of a right angle to the palatal suture in the maxillary arch [6].

Fig 1: Intercanine width measurement.

Fig 2: Intermolar width measurement

The crowding was calculated by subtracting the needed space from the available space in the upper arch of the study models.

Photographic analysis

Standard-posed frontal smile photographs of samples before and after treatment were evaluated using Digimizer image analysis software (Version 4.1.1.0; MedCalc Software, Mariakerke, Belgium) **(Figs 3 and 4)** for the width of the buccal corridor in relation to canines and the last visible tooth **(Figs 5 and 6).**

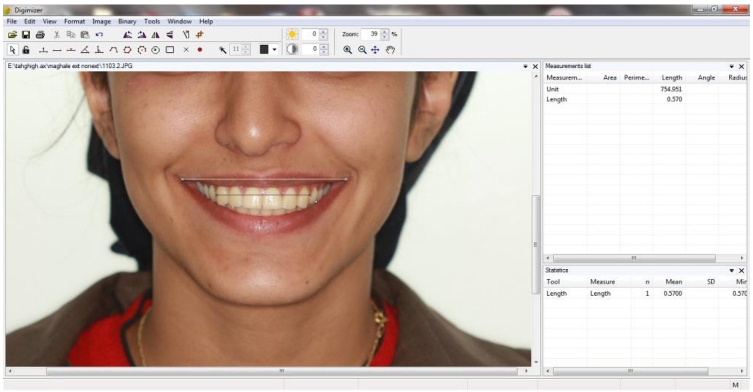

Fig 3: Digimizer software environment

Measurements list

Measurem...	Area	Perime...	Length	Angle	Radiu
Unit			754.951		
Length			0.570		

Fig 4: The buccal corridor width was calculated in relation to canines.

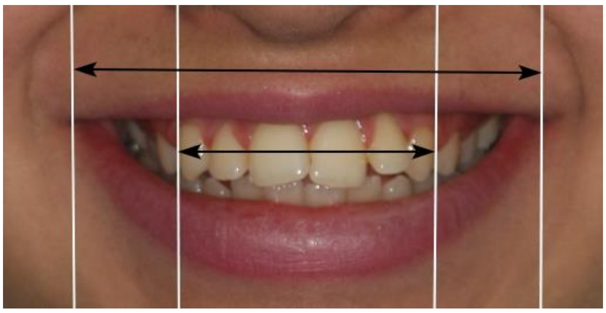

Fig 5: The buccal corridor width was measured in relation to canines as the ratio between intercanine width and smile width

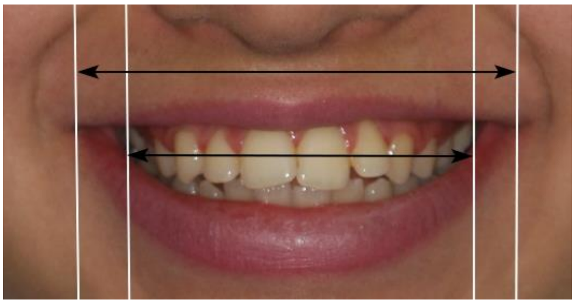

Fig 6: The buccal corridor width was measured in relation to the last visible tooth as the ratio between the last visible tooth width and smile width.

Photographic records were taken with a digital camera (EOS 40D; Canon, Japan) and a macro lens (EF 100 mm, f/2.8 Macro USM; Canon).

In selecting cases for this study, we tried to include subjects with photographs of natural posed smiles both before and after treatment. Some patients were excluded because of unnatural smiles in pre-treatment and post-treatment photographs **(Fig 7).**

Fig 7 :**Smile photograph is not of a naturally posed smile.**

Similarity of pre-treatment and post-treatment smiles was checked by comparing the ratio of the inter-canthal and inter-commissure widths before and after treatment, using the Digimizer software and then the correlation of these ratios was analyzed with SPSS software **(Fig 8).** The inner inter-canthal width is a fairly stable part of this ratio [13].

Fig 8: Comparison of the ratio of the inter-canthal and inter-commissure widths before and after treatment using the Digimizer software.

Method error study

Model and photographic measurements were repeated one month later on 10 randomly selected cases from each group. The intra-examiner agreement was evaluated using the intra-class correlation coefficient (ICC) for measurements at a 95% confidence interval.

STATISTICAL ANALYSIS

All the statistical analyses were performed using SPSS (Version 21; IBM). We used the Shapiro-Will test to check normal distribution of data in the groups. Descriptive statistics were used for all the demographic, model and photographic measurements. For testing homogeneity, we conducted independent t-test between the groups among the potential confounding variables (age, gender, treatment time, ANB and upper crowding). The factors that differed significantly between groups before treatment were considered as confounding factors. Univariate analysis of covariance was used to compare the two treatment groups for all the model and photographic variables that were adjusted by determined confounding factors.

Then partial correlation coefficients were determined to evaluate any significant relationships between arch width and buccal corridor width changes. Statistical significance was set at P<0.05.

We checked similarity of pretreatment and post-treatment smiles by comparing the ratio of the inter-canthal and inter-commissure widths before and after treatment and calculating the correlation coefficient.

RESULTS

The Shapiro-Will test showed normal distribution of data in the groups. Descriptive statistics for all the demographic measurements are presented in Table 1. In the extraction group, the mean intercanine width increased 1.16 mm but the mean intermolar width decreased 0.83 mm. In the non-extraction group, both the mean intercanine and intermolar width exhibited a little increase after treatment (0.36 mm and 0.13 mm, respectively). Independent t-test showed that of the considered potential confounding variables (age, gender, treatment time, ANB and upper crowding), upper crowding and ANB were significantly different between the two groups before treatment. Therefore, these two variables were considered as confounding factors. Univarite analysis of covariance showed that post-treatment intermolar width with adjustment of ANB, upper crowding and pretreatment intermolar width was different between the two groups (P=0.006) (Table 2), but this test did not show any significant differences for post-treatment intercanine width, post-treatment buccal corridor width in relation to canine and the last visible tooth.

We evaluated correlations between arch width and buccal corridor width changes (Table 3). There was a significant and positive correlation between intercanine width change and buccal corridor width change in relation to the canines. Other correlations between arch width and buccal corridor width changes were not significant. The similarity between the pre-treatment and post-treatment smile photographs of selected cases on the basis of inter-canthal–inter-commissure ratio was high (Pearson's correlation coefficient=0.898). Intra-class correlation coefficients for model and photographic variables were from 0.93 to 0.99.

Table 1: Descriptive statistics for demographic variables

		Age		Upper crowding		ANB		Treatment time	
Group	**Sex**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Extraction	**M (n=4)** **F (n=25)**	16.65	5.03	4.86	2.95	3.91	1.83	2.59	0.37
Non-extraction	**M (n=10)** **F (n=20)**	17.88	6.28	2.21	1.81	2.65	2.18	2.48	0.20
Total	**M (n=14)** **F (n=45)**	17.28	5.68	3.51	2.76	3.27	2.10	2.53	0.30

Table 2: Univariate analysis of covariance for model and photographic variables

Post-treatment dependent variable	Group mean square	Group significance
Intercanine width	1.23	0.420
Intermolar width	11.21	0.006
IC:SW°	0.005	0.787
VD:SW•	0.006	0.061

*Fixed factor: group
*Covariates: ANB, upper crowding and pre-treatment value of variable
IC: SW°: Ratio between intercanine width and smile width
VD: SW•: Ratio between the last visible tooth width and smile width

Table 3: Partial Pearson's correlation between arch width changes and buccal corridor width changes in both groups

	r value	
	Intercanine width change	**Intermolar width change**
IC:SW° change	0.406*	-0.043
VD:SW• change	-0.007	0.167

*Correlation is significant
IC: SW°: Ratio between intercanine width and smile width
VD: SW•: Ratio between the last visible tooth width and smile width

DISCUSSION

In the first part of this study, we found that with the adjustment of confounding factors, post-treatment intermolar width decreased in the extraction group significantly compared to that in the non-extraction group. In the second part, we found that with the adjustment of confounding factors, the buccal corridor width in relation to canines and the last visible tooth were not different between the two groups. There was a positive correlation between the buccal corridor width change in relation to canines and intercanine width change.

The effect of tooth extraction on a decrease in the anteroposterior arch dimension is clear. The unsuccessful camouflage treatment resulting from extraction of premolars and retruded lips prove this effect, but whether these extractions and space closure do affect transverse arch dimension as well as anteroposterior dimension is the topic of this discussion.

Conventionally, arch widths have been measured between the cusp tips of the canines and molars [6,14–18], but buccolingual inclination of teeth before and after treatment is likely to be different and in this study in order to determine the widest possible anterior and posterior widths of the arches, we measured intercanine and intermolar widths from the most labial aspect of the buccal surfaces.

It is logical to think that in cases treated without extraction and distalization, the crowding is resolved by protrusion of incisors and buccal expansion of canines and posterior segments. In the present study, intercanine and intermolar width in the non-extraction group did not increase significantly after treatment. Gianelly reported similar results [6], but Kim [16], Asku [11] and Bishara [9] found increased intercanine and molar width in the non-extraction group. Our finding might be attributed to the greater contribution of incisor protrusion than buccal expansion in the relief of crowding in non-extraction cases.

In extraction cases, it seems that intermolar width will decrease because of the geometry of dental arch that becomes narrower anteriorly unless orthodontic expansion is carried out. In the present study, the intermolar width decreased after treatment in the extraction group, indicating some anterior movement of molars during space closure. This is consistent with reports by Kim [16], Bishara [9] and Asku [11]. Depending on initial crowding and its location, different situations might arise for canines. If crowded canines are blocked out buccally, extraction treatment results in favorable tooth position, and intercanine width seems to decrease. If canines are not out of the arch, they seem to move back to the greater arch width during space closure, consistent with our results in the extraction group.

It seems that with the first molar's anterior movement, the second molar will move forward equally and will be in the previous location of the first molar. Therefore, although the molar moved anteriorly and the intermolar width decreased, relative to a fixed reference point, for example from the incisive papilla, dentition width did not change significantly. This may be the reason why in this study the buccal corridor width, in relation to the last visible tooth, was not different between the two groups after treatment. It seems that, by posterior movement of canines in extraction treatment, the buccal corridor in relation to canine would increase. Interestingly, Isiksal et al [5] reported this effect, but our study did not confirm this. There was no significant correlation between the buccal corridor width change in relation to the last visible tooth and the intermolar width change. Therefore, the present study does not support the results indicating a direct effect of arch width changes on the buccal corridor [14,19].

Concerning measurements of the buccal corridor width in relation to canines, two errors may exist:

1. A potential error can arise from underestimating the buccal corridors when in photographs of few cases buccally blocked-out canines exist. After aligning and leveling and space closure in extraction cases the intercanine width is likely to decrease **(Fig 9).**
2. Another error may be the difficulty of measuring the initial buccal corridor width exactly parallel to the smile width because of displaced and crowded canines or asymmetrical lip elevation in smile **(Fig 10).**

Because of these errors, the buccal corridor, in relation to canines, might not be a highly reliable variable. We believe measuring the buccal corridor in relation to the last visible tooth is more precise.

Fig 9: Pre-treatment blocked-out canine.

Fig 10: Difficulty of measuring pre-treatment buccal corridor width exactly parallel to the smile width.

The buccal corridor width is one of the smile characteristics. We did not focus on other features like smile line, as well as gingival and incisor display. These parameters may be more or less important in attractiveness of smile and premolar extraction may also affect these parameters. Further investigations are necessary to evaluate the effect of premolar extraction on all the features of smile.

What we measure as the buccal corridor is a quantitative variable on a static record of one moment of smile, but smiling is a dynamic process which should be recorded by digital videography in a dynamic way to precisely evaluate its characteristics.

CONCLUSION

1. Compared to non-extraction treatment, intermolar width decreased after extraction of premolars.
2. Post-treatment intercanine width was not significantly different between extraction and non-extraction procedures.
3. Post-treatment buccal corridor width in relation to canines and the last visible tooth was similar between extraction and non-extraction treatment modalities.
4. There was a positive correlation only between the buccal corridor width change in relation to canine and intercanine width change. Other possible correlations between the buccal corridor width and arch width were not detected.

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