Доклади на Българската академия на науките
Comptes rendus de l'Académie bulgare des Sciences
Tome 76, No 9, 2023

MEDICINE

Oral medicine

CORRELATION BETWEEN THE CROWDING SEVERITY, THE AMOUNT OF IPR AND THE NUMBER OF TEETH MOVED

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Received on August 31, 2020
Presented by D. Damianov, Member of BAS, on October 29, 2020

Abstract

The aim of this study is to determine the relationship between the severity of crowding, the need of the interproximal enamel reduction (IPR, stripping), and the number of moved teeth.

One hundred and twenty-seven patients aged from 18 to 62 years, of whom 99 (78%) women and 28 (22%) men in need of active orthodontic treatment were included in the study. All patients underwent orthodontic treatment with DENT@LIGN digital aligners on etsablished protocol. The severity of crowding and the amount of IPR were measured.

The stripping is coded in six groups, based on amount ($\leq$ 1 mm; 1.1 to 2.0 mm; 2.1 to 3.0 mm; 3.1 to 4.0 mm; 4.1 to 5.0 mm, and greater than 5.1), and the crowding in four groups: no crowding; mild crowding (0.1 mm to 3.0 mm); moderate crowding (3.1 mm to 7.0 mm); severe crowding (over 7.1 mm).

The Spearman test showed a significant positive correlation between stripping size and crowding severity in both jaws. In the upper jaw the correlation coefficient is $r^s = 0.430$, $p < 0.001$. In the lower jaw, the correlation coefficient was higher ($r^s = 0.514$), $p < 0.001$.

The results of the Pearson test showed a direct proportional relationship between the number of teeth in need of movement and the size of stripping in the upper and lower jaws.

Based on the number of moved teeth, the size of the stripping can be predicted by the following formulas: Upper jaw stripping (mm) = $-0.3891 + 0.1711\times$ Number of moved teeth, with predictive value of R-square = 17.2%;

DOI:10.7546/CRABS.2023.09.17

Lower jaw stripping (mm) = $-0.8965 + 0.2773\times$ Number of teeth moved, with predictive value of R-square = 28.1%.

Key words: aligners, crowding, orthodontics, interproximal enamel reduction

Introduction. Interproximal enamel reduction (IPR, stripping) is a procedure, part from the orthodontic treatment that includes reduction, anatomical reconstruction and protection of the approximal enamel surfaces in permanent teeth. With this method we get space in the dental arch and support a solution for non-extraction treatment for correction of mild to moderate crowding (up to 7 mm) as an alternative to extraction treatment or/and expansion. The tooth-size discrepancy according to Tonn and Bolton is decreased, and the discrepancy between the tooth size and dental arch perimeter is reduced [1, 2]. It allows aesthetic reshaping of the teeth and normalization of the gingival contour with the elimination of triangular spaces as prevention and treatment of interdental gingival recessions [3, 4].

The use of IPR in the aligner treatment has several advantages. The mechanics of these appliances allows full control of the anchorage, the soft tissues are protected, the labial and lingual surfaces of the teeth are protected, too. Only the approximal surfaces are treated, through access provided by preliminary separation. The treatment time is reduced and the quality of the treatment is improved. The treatment is also aesthetical and with possibility for complete fluoride prophylaxis. At any moment the intercuspidation and the midline are controlled, the distance from the contact point to the bone is easily measured [5, 6].

Proper IPR procedure includes 4 main stages:

– Reduction of interproximal enamel

– Reshaping of the tooth surface

– Polishing

– Remineralization

The aim of the present study is to determine the relationship between the crowding severity, the amount of interproximal enamel reduction (IPR, stripping) and the number of moved teeth.

Materials and methods. The study included 127 patients aged from 18 to 62 years, of whom 99 (78%) women and 28 (22%) men in need of active orthodontic treatment. All patients underwent orthodontic treatment with DENT@LIGN digital aligners. Casts before and after treatment were observed. A biometric analysis, a virtual set up and a treatment plan were made, which determine the number of teeth to be moved. The severity of crowding and the amount of IPR were measured.

The stripping is coded in six groups, based on the amount ($\leq$ 1 mm; 1.1 to 2.0 mm; 2.1 to 3.0 mm; 3.1 to 4.0 mm; 4.1 to 5.0 mm, and greater than 5.1), and the crowding in four groups: no crowding – without lack of space; with mild

crowding – lack of space from 0.1 mm to 3.0 mm; with moderate crowding – lack of space from 3.1 mm to 7.0 mm; with severe crowding – lack of space over 7.1 mm.

The relationship between the severity of the crowding and the amount of the IPR in both the upper and lower jaw was assessed by the Spearman test.

To investigate the relationship between crowding severity, the amount IPR, and the number of moved teeth, a correlation analysis was performed that was consistent with the type of data. To analyze ordinal data, we used the Spearman rank-order correlation test and the Pearson r correlation test for data measured on a continuous scale. The correlation coefficients are interpreted against the Cohen reference values (Cohen, 1988) as follows:

- very high/high correlation: ± (0.70–1)
- high/high correlation: ± (0.50–0.69)
- medium/moderate correlation: ± (0.30–0.49)
- low/low correlation: ± (0.10–0.29).

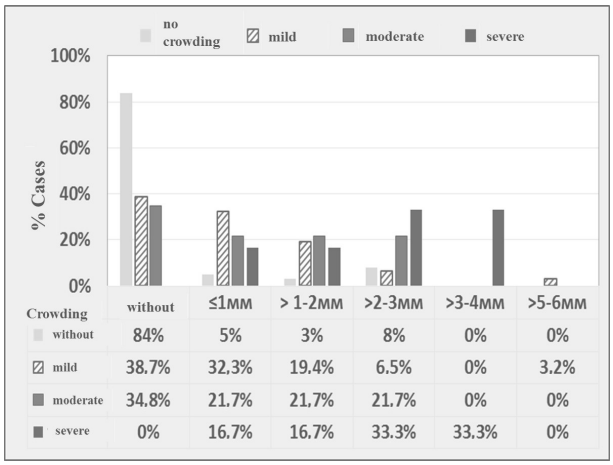
Results. The results of the Spearman test on the correlation between the stripping and the severity of the crowding in the upper and lower jaw are summarized in Table 1. A significant positive correlation was observed in both jaws. In the upper jaw, the correlation coefficient is $r^s = 0.430$, which according to Cohen's reference intervals indicates a moderate correlation between the amount of the stripping and the severity of crowding, $p < 0.001$. In the lower jaw, the correlation coefficient has a higher value ($r^s = 0.514$), meaning that there is a high correlation between the stripping and the severity of crowding, $p < 0.001$.

T a b l e 1

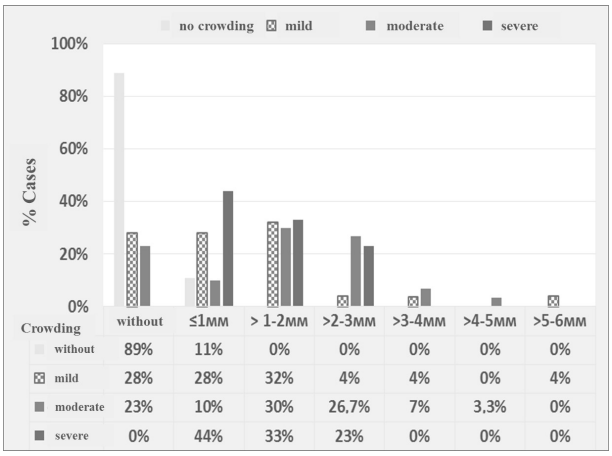
Correlation between the stripping and the severity of crowding in the upper and lower jaw

Value	Statistics	Severity of the cases in the upper jaw	Severity of the cases in the lower jaw
Stripping in the upper jaw	Coefficient r^s	0.430	–
	Significance (p)	0.000^{**}	–
Stripping in the lower jaw	Coefficient	–	0.514
	Significance (p)	–	0.000^{**}

The relationship between the severity of the crowding and the amount of the IPR in the upper jaw is presented in Fig. 1a. Statistically significant correlation can be explained by the following two main trends: 1) The highest percentage of cases without stripping (84%) is in the group of patients without crowding. There are very few cases of stripping in the same group and they are completely absent in the last two groups – $> 3{-}4$ and $> 5{-}6$ mm. 2) In patients with severe crowding, no cases without stripping were observed and the highest percentage of cases with stripping was reported in the groups – $> 2{-}3$ and $> 3{-}4$ mm.



a



b

Fig. 1. Distribution of patients according to the severity of the crowding and the amount of the applied stripping: a) in the upper jaw; b) in the lower jaw

The following trends are outlined in the lower jaw (Fig. 1b): 1) In patients without crowding, the highest percentage of cases without stripping is observed (89%), and the remaining 11% are in the lowest amount category ≤ 1 mm. 2) In patients with severe crowding, no cases without stripping were observed. 3) Most cases of larger amounts of stripping are found in patients with moderate crowding.

The results of the Pearson test on the correlation between stripping and the number of displaced teeth in the upper and lower jaw are summarized in Table 2. There is a significant positive correlation between the size of the stripping (mm) and the number of teeth moved in the upper and lower jaw. A moderate positive correlation was observed in the upper jaw ($r = 0.430$, $p < 0.001$), which indicates a systemic correlation between the amount of stripping and the number of moved teeth. Higher amounts of stripping are associated with a greater number of moved teeth. In the lower jaw there is a high positive relationship between the amount

of the stripping and the number of moved teeth ($r = 0.530$, $p < 0.001$). Patients with more displaced teeth are associated with greater amount of stripping (mm).

Table 2

Correlation between stripping and the number of moved teeth in the upper and lower jaw

Value	Statistics	Number of aligned teeth in the upper jaw	Number of aligned teeth in the lower jaw
Stripping in the upper jaw	Coefficient r^s	0.415	–
	Significance (p)	0.000^{**}	–
Stripping in the lower jaw	Coefficient	–	0.530
	Significance (p)	–	0.000^{**}

To illustrate more accurately the relationship between the size of the stripping (mm) and the number of moved teeth, dot charts and regression equations have been compiled, which can be used to predict the size of the stripping depending on the number of moved teeth (Fig. 2).

In the upper jaw, based on the number of moved teeth, the size of the stripping can be predicted according to the following formula: Stripping upper jaw (mm) $= -0.3891 + 0.1711\times$ Number of moved teeth in the upper jaw. The formula has a prognostic value R-square = 17.2%.

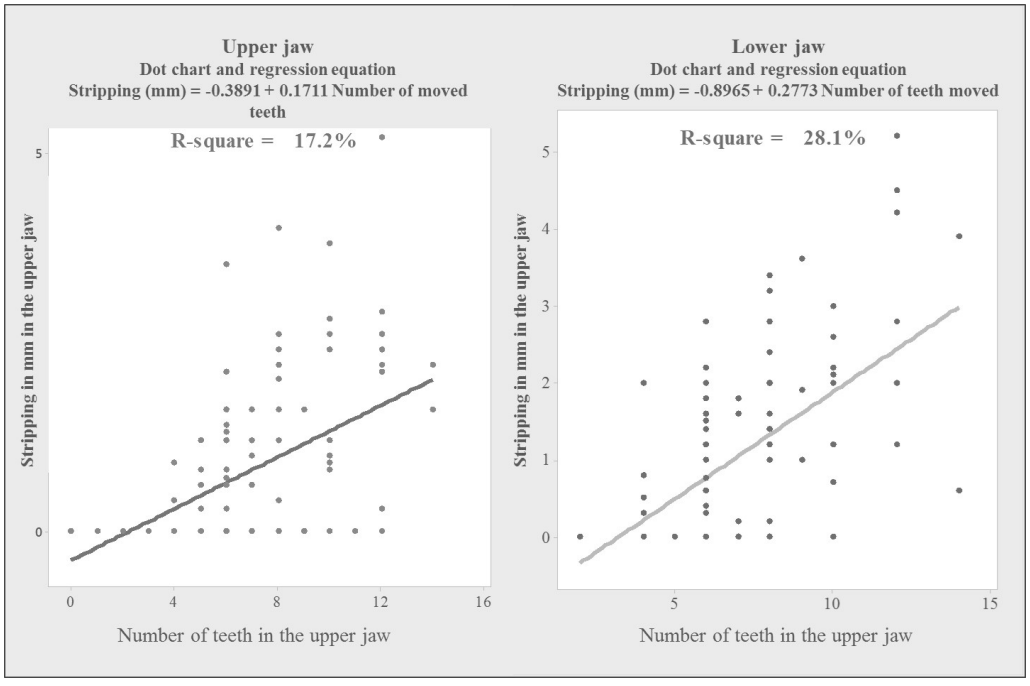


Fig. 2. Dot charts and regression equations for the relationship between the amount of the stripping (mm) and the number of teeth moved in the upper and lower jaw

In the lower jaw, the prognostic equation is as follows: Stripping lower jaw (mm) = −0.8965+0.2773× Number of moved teeth in the lower jaw. The equation has a prognostic value R-square = 28.1%.

Discussion. We use IPR as an alternative method to tooth extraction treatment for the levelling of teeth in the dental arch. The use of IPR has been accepted as a treatment method and a number of studies have shown that it does not lead to an increased risk of caries. Zachrisson et al. [4] found no evidence that enamel reduction within certain limits leads to a violation of tooth integrity and suggested that it does not damage tooth structures [4, 7, 8]. Zheng [9] demonstrates that IPR reduces the severity of periodontal risks after orthodontic treatment, shortens the duration of treatment, improves aesthetics, prolongs the life of the dentition [9]. According to the research of Jarjoura et al. [10] the IPR technique does not lead to increased caries risk [4, 10, 11]. In general, the relative proportion of patients with lower jaw stripping is higher according to studies [9–11].

One of the main problems in orthodontics is the lack of space to arrange the teeth in the dental arch. In non-growing patients, the expansion of the dental arch in the area of the canines as a treatment method of crowding, has an unstable result and prognosis and requires lifelong retention with a fixed retainer [11, 12]. An alternative for creating space in the dental arch without changing its width and perimeter is the application of IPR [11, 13–15].

Our analysis includes regression graphs, regression equations and values of the coefficient of determination R-square. The regression equations present formulas on the basis of which the amount of the stripping can be predicted from the number of teeth for which displacement is planned or expected.

Conclusion. Based on the moved teeth, we can predict the amount of the stripping with an accuracy of 17.2% in the upper jaw and 28.1% in the lower. The remaining percentages are due to other factors, such as the severity of crowding and individual characteristics of the patients.

The treatment management with DENT@LIGN aligners in patients with different severity of malocclusion allows predictable and controlled treatment.

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