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Frequency of Orthodontic Extractions and Malocclusion-Related Factors in a University Setting During a 25-Year Period

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Objectives The decision regarding orthodontic tooth extraction or dental arch expansion is an important yet challenging topic in orthodontic treatment planning. However, studies in this respect are limited In Iran. This study aimed to assess the frequency of orthodontic tooth extractions and the role of malocclusion-related factors that affect the frequency of orthodontic extractions in a university setting during 25 years.
Methods This descriptive retrospective study evaluated 1,222 records of patients who underwent fixed orthodontic treatment in Shahid Beheshti Dental School from 1994 to 2018. The frequency of tooth extraction, type of malocclusion, and age and gender of patients were analyzed by the Chi-square test. The correlation of quantitative and qualitative variables related to occlusion (overjet, overbite, space discrepancy, cross-bite, A point–nasion–B point angle, mandibular plane angle, canine relationship, molar relationship, and the Curve of Spee) with orthodontic extraction was analyzed by the binary logistic regression. All statistical analyses were performed by SPSS version 21.
Results The frequency of orthodontic extraction decreased from 1994 (74.5%) to 2018 (41.6%). The highest frequency of orthodontic extraction (60%) occurred in class II division I malocclusion cases. Frequency of orthodontic extraction in the age group of 12-20 years was significantly higher than in other age groups (P=0.003). The odds of orthodontic extraction increased by an increase in overjet (P=0.036) and in class II malocclusion cases (P=0.05), and decreased by an increase in overbite (P=0.020).
Conclusion Tendency to orthodontic extraction has decreased in contemporary orthodontics in Shahid Beheshti Dental School. In addition to the degree of dental crowding, the decision regarding orthodontic extraction also depended on overjet, overbite, and type of malocclusion.
Keywords Malocclusion; Orthodontics; Tooth Extraction

Introduction

The decision regarding orthodontic tooth extraction or dental arch expansion has always been a challenging topic in orthodontic treatment planning. [1, 2] Expansion of dental arch often results in further protrusion of the teeth. Conversely, tooth extraction would result in collapse of the arch form, and its main drawback is the loss of functional teeth.[3, 4] However, orthodontic extraction reportedly has the advantage of higher stability of the treatment results. Orthodontic extraction may eventually have a positive or negative impact on facial esthetics. [5, 6] No information is available regarding the number of patients that can be reliably treated by either extraction or non-extraction orthodontic treatment, or regarding the number of patients for whom, selection of extraction or non-extraction orthodontic treatment is a major decision, and has a great impact on their treatment outcome. [7, 8] Although this decision has no significant effect on the efficacy of mastication, it is an important decision for patients. [9, 10]

Variable rates have been reported for the frequency of orthodontic extraction ranging from <25% to >80%. [11-13] A 40-year study by Proffit [14] on 6,000 patients presenting to North Carolina University reported that the frequency of tooth extraction in fixed orthodontic treatment increased from 30% in 1953 to 76% in 1968, and then decreased to 28% in 1993. Most of the fluctuation was related to the selection of four premolars for extraction. Janson and Maria [12] evaluated the frequency of orthodontic extraction in a 35-year period in Brazil, and reported that the frequency of tooth extraction decreased from 86% in 1973 to 46% in 2007. The same trend was reported for the frequency of extraction of four premolars. They suggested variables such as the correlation of tooth extraction and temporomandibular joint dysfunction, and changes due to growth modification, interproximal reduction, and maxillary expansion as the main reasons for reduction of orthodontic extraction. Jackson et al. showed slight linear reduction in this respect in North Carolina University from 2000 to 2011. They also demonstrated that in addition to dental crowding, the frequency of orthodontic extraction increased by increase in overjet, reduction in overbite, and class II malocclusion. [7] A small linear reduction in overall frequency of orthodontic extraction and in extraction of all four first premolars was also reported. Dardengo et al, [8] in their study regarding the frequency of orthodontic extraction in 1,484 patients treated in the Universidade Estadual do Rio de Janeiro during 32 years indicated 20% reduction in the frequency of orthodontic extraction due to esthetic considerations; first premolars were the most commonly extracted teeth for orthodontic purposes. They found no significant difference in the frequency of

orthodontic extraction in terms of gender (P=0.177). The minimum and maximum frequency of extraction were noted in class I and class II malocclusion cases, respectively.

The decision regarding orthodontic extraction requires thorough evaluation of dental, facial, and skeletal parameters. Patient cooperation, facial profile, skeletal age, dental asymmetry, anteroposterior relationship of the jaws, and presence of anomalies are also among the influential factors in selection of extraction orthodontic treatment. [15-19] At present, concerns regarding increased esthetic facial aging should also be taken into account in orthodontic treatment planning. [3, 4] Some studies showed that extraction orthodontic treatment did not change the facial height [5, 7, 11, 16]; while, some others demonstrated that orthodontic extraction increased the inclination angle of the chin and decreased the lower lip protrusion, compared with non-extraction treatment. [20, 21]

Advances in orthodontic bonding and introduction of different techniques such as self-ligated brackets, temporary anchorage devices, functional appliances, and interproximal reduction have significant effects on orthodontic treatment planning. [14] Thus, orthodontic treatment plans and space management in orthodontics are not limited to extraction or non-extraction approaches. [15] Despite the increasing publicity on the expansion treatment and space gaining in dental arch, orthodontic extraction is still considered in orthodontic treatment planning to improve facial appearance and obtain stable results. [16]

Considering the broad range of orthodontic treatments, knowledge about the frequency of orthodontic extraction at present, compared with before, and the influential factors in this regard is imperative. [1, 3-6] Also, knowledge about the patient-related factors that have a significant effect on selection of orthodontic extraction can greatly help in orthodontic treatment planning based on patient-related parameters. Such information can also be used in orthodontic educational programs. It appears that assessment of the frequency of orthodontic extraction and the influential factors in this respect is important for decision making regarding the selection of extraction treatment plan, and can enhance promotion of orthodontic science. However, limited number of retrospective studies have addressed this topic. Studies in this respect are also limited in Iran; therefore, this study aimed to assess the frequency of orthodontic extraction and the influential factors in this respect by evaluating 1,222 patient records during a 25-year period. The results of this study can provide an epidemiological model of influential diagnostic factors in orthodontic extraction and this research might be of particular use in orthodontic training programs to aid future generations of orthodontists.

Methods and Materials

In this descriptive retrospective study, the archives of the Orthodontics Department of Shahid Beheshti University of Medical Sciences were searched for patient records from 1994 to 2018 (ethical approval code: IR.SBMU.DRC.REC.1397.044). A total of 2,000 records of patients who received fixed orthodontic treatment from 1994 to 2018 (5 periods, each for 5 years) were selected by convenience sampling. Patient records with incomplete information regarding the treatment plan or patient information, or those reporting tooth extraction (third molars, primary teeth, etc.) for non-orthodontic reasons (such as dental caries, periodontitis, orthognathic surgery, or cleft lip and palate), congenitally missing teeth, dentofacial anomalies, significant facial asymmetries, surgical treatments, treatment dropouts or discontinued treatment cases, and patient transfers were excluded. [22-26] Eventually, data of 1,222 patient records regarding age, gender, class of malocclusion (Angle's classification) [27], treatment plan, and age at the time of treatment onset (6-12 years, 12-20 years, > 20 years) were extracted. Also, several parameters related to the extraction and non-extraction orthodontic treatment plans such as overjet, overbite, Curve of Spee (0-1 mm: normal, 2-3 mm: moderate, > 3 mm: excessive) [27, 28], space discrepancy, cross-bite, canine and molar relationships, skeletal classes in horizontal and vertical dimensions, ANB (A point, nasion, B point angle), and mandibular plane angle (according to the Steiner's analysis) were retrieved from patient records between 1994-2018. [22-24]

The recommended treatment plans of patients were categorized into 6 protocols of 0 (non-extraction), 1 (extraction of four premolars), 2 (extraction of two maxillary/mandibular premolars), 3 (asymmetric extraction) (three premolars or one premolar), 4 (extraction of lower incisors), and 5 (first or second molar extraction). This was done to assess the frequency of each recommended protocol in 25 years in five periods of five years each. Eventually, data of eligible patient records were extracted and analyzed. The Chi-square test was used to analyze the correlation of type of treatment protocol recommended and type of malocclusion. The binary logistic regression was applied to assess the correlation of factors such as overjet, overbite, space discrepancy, Curve of Spee, dental malocclusion, skeletal malocclusion, and mandibular plane angle with orthodontic extraction recommended, and their effects on the odds of selection of extraction orthodontic treatment. P values < 0.05 were considered statistically significant.

Results

Assessment of the data obtained from 1,222 patient records during 25 years indicated that the frequency of orthodontic extraction decreased from 1994 (74.5%) to 2018 (41.6%)

(Figure 1).

Comparison of quantitative variables in orthodontic patients between 1994-2018 showed that the mean amount of overjet, overbite, mandibular/maxillary space discrepancy (P<0.001) and the mean SN-MP (MPA) (sella-nasion/mandibular plane angle) (P=0.013) were significantly different between patients with extraction and non-extraction orthodontic treatments. However, the mean degree of ANB angle (P=0.951) and age (P=0.835) were not significantly different between the two treatment plans. Table 1 presents the qualitative variables of patients with extraction and non-extraction orthodontic treatment plans during 25 years.

Figure 1. Frequency of extraction and non-extraction orthodontic treatments during 1994-2018

Table 1- Characteristics of qualitative variables in patients with extraction and non-extraction orthodontic treatments during 1994-2018

Characteristics of extraction patients (n=661)			**Characteristics of non-extraction patients (n=561)**		
Curve of Spee	Normal: 36.8%	Moderate: 43.7% Excessive: 19.5%	Normal: 27.4%	Moderate: 51.9%	Excessive: 20.7%
Canine relationship	I :34.5% II: 50/3%	III: 15.1%	I: 39.8% II: 44.7%	III:15.8%	
Molar relationship	I :34.5% II: 47.2%	III: %17.2	I: 46% II: 35%	III:19%	
Crossbite	No: 28.8%	Posterior crossbite: 22.8% Anterior crossbite: 48.5%	No: 37.2%	Posterior crossbite: 28.7% Anterior crossbite: 34%	
Gender	Female: 58.2%	Male:42.8%	Female:62.6%	Male:37.4%	

Comparison of extraction and non-extraction orthodontic treatment plans in different malocclusions showed the frequency of extraction orthodontic treatment to be 60% in class II division 1 patients, compared with non-extraction treatment. This rate was higher in class II division 1 malocclusion compared with other malocclusions. The frequency of extraction orthodontic treatment was 42% in class II division 2 malocclusion; this rate was lower in this malocclusion compared with other malocclusions (P=0.002). In other words, the highest frequency of orthodontic extraction was noted in class II division 1 and the lowest frequency was noted in class II division 2 cases (Figure 2).

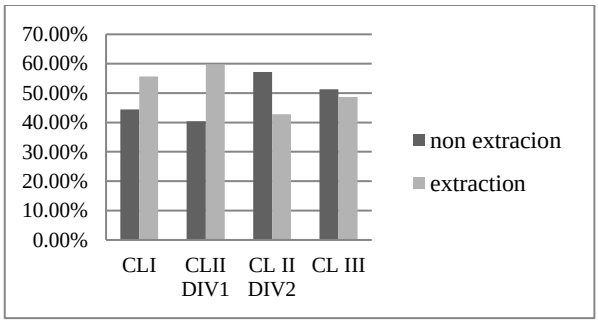

Figure 2. Comparison of extraction and non-extraction orthodontic treatment plans in different malocclusions

The frequency of extraction orthodontic treatment was not significantly different between males and females (P=0.317). The frequency of extraction orthodontic treatment in 12-20-year-olds (58%) was higher than that in 6-12 (42%) and > 20-year-olds (48%) (Figure 3).

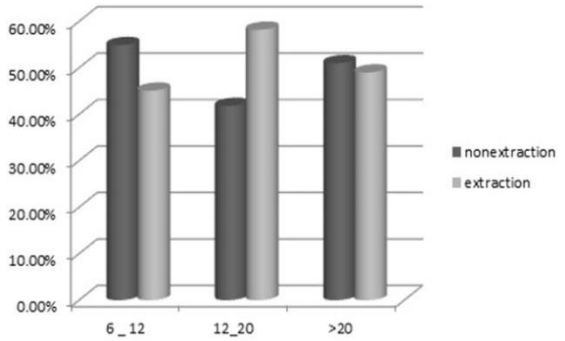

Figure 3. Comparison of extraction and non-extraction orthodontic treatment plans in different age groups

The greatest change occurred in the frequency of four-premolar extraction, and non-extraction treatment plans over 5 periods each for 5 years, which decreased and increased, respectively until 2018. During 2009-2018, the increase in frequency of non-extraction orthodontic treatment was significant (Figure 4).

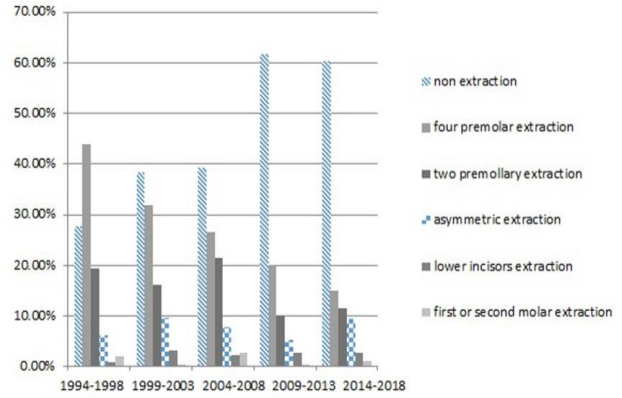

Figure 4. Frequency of different orthodontic treatment plans during 25 years

Table 2 presents the results of binary logistic regression, indicating that the odds of extraction treatment plan in patients with increased overjet were 1.730 times higher than in patients with normal overjet (P=0.036). The odds of extraction orthodontic treatment in patients with increased overbite were lower than normal-overbite patients (P=0.020). By an increase in space discrepancy (from negative or crowding towards positive or spacing), the odds of selection of extraction orthodontic treatment decreased (P=0.00). The odds of selection of extraction orthodontic treatment were higher in class II patients than other groups (P=0.05).

Table 2- Correlation of overjet, overbite, space discrepancy, crossbites, ANB, mandibular plane angle, canine malocclusion, molar malocclusion, and Curve of Spee with the selection of extraction orthodontic treatment plan

Characteristics	Odds Ratio	95% CI	P-value
Decreased overjet < 1mm	0.857	0.416 – 1.765	0.675
Increased overjet > 2 mm	1.730	1.036 – 2.888	0.036
Decreased overbite < 1 mm	1.163	0.580 – 2.331	0.671
Increased overbite > 2 mm	0.545	0.327 – 0.910	0.020
Molar malocclusion CL II	1.952	0.991 – 3.845	0.053
Molar malocclusion CL III	1.361	0.581-3.191	0.478
Canine malocclusion CL II	0.836	0.427 – 1.636	0.602
Canine malocclusion CL III	0.936	0.377– 2.325	0.886
Curve of Spee (moderate , severe)	0.649	0.364-1.155	0.142
Unilateral posterior crossbite	1.157	0.362-3.687	0.807
Bilateral posterior crossbite	0.672	0.151- 2.987	0.602
Anterior crossbite	1.652	0.691-3.952	0.259
Space discrepancy	0.787	0.727-0.852	<0.001
ANB	0.981	0.890 _ 1.082	0.704
Mandibular plan angle (MPA)	1.029	0.982_ 1.078	0.228

Discussion

The decision regarding tooth extraction is an important yet challenging topic in orthodontic treatment planning. However, studies in this respect are limited in Iran; therefore, this study assessed the frequency of orthodontic extraction and the influential factors in this respect by evaluating 1,222 patient records in a 25-year period.

The present results, in line with the findings of many other studies, indicated a reduction in the frequency of orthodontic extraction from 1994 to 2018. Reduction in frequency of orthodontic extraction was also indicated by Proffit [14] during a 40-year period, Moreira and Mucha [29] during a 30-year period, Janson and Maria [12] during a 35-year period, and Jackson et al, [7] during an 11-year period. It appears that changes in the esthetic standards over time and the increased variability in treatment plans and orthodontic appliances for treatment of malocclusions such as expander systems, distalizer devices, functional and orthopedic appliances, temporary anchorage devices, and increased frequency of interproximal reduction are among the reasons for decreased frequency of orthodontic extraction. [7, 29-31] Moreover, introduction of bonded brackets and their use instead of banding of all teeth decreased the frequency of orthodontic extractions. Conversely, long-term studies such as the one by Proffit [14] revealed that in patients with extraction treatment plan, the expected stability of treatment results did not occur, which gradually led to reduction in frequency of orthodontic extraction.

The present study, similar to that of Dardengo et al. [8] found no significant difference in the frequency of orthodontic extractions between males and females. Also, in line with other studies, the present study showed that first premolars were the most commonly extracted teeth in orthodontic treatment (49.7%), which can be due to their position in dental arch. Extraction of first premolars is more suitable for correction of midline deviation and space shortage in the anterior region. [6, 14, 32]

The asymmetric extraction protocol (three-premolar extraction) is indicated in class II subdivisions. [26] Another version of this treatment plan in class II malocclusion would include extraction of one premolar. [26, 28] In the present study, the frequency of this protocol was high from 1994 to 2003 similar to the study by Janson and Maria [12] and then slightly decreased and increased again between 2014 to 2018. However, the frequency of this protocol was initially low in the study by Janson and Maria [12] and then considerably increased from 1994 and reached its

maximum percentage in 2002, and subsequently slightly decreased; this pattern may be due to the fact that the asymmetric extraction protocol brings about more successful results than four-premolar extraction. [26] Also, it causes lower retraction of the soft tissue and mandibular incisors. [22] The frequency of orthodontic extractions was not correlated with Angle's classification in a study by Moreira and Mucha. [29] On the other hand, Dardengo et al. [8] reported that class I malocclusion had the lowest (43%) and class II malocclusion had the highest (49%) frequency of orthodontic extraction. In the present study, similar to that of Dardengo et al, [8] the maximum frequency of orthodontic extractions was noted in class II division 1 cases (59.6%). In the study by Dardengo et al, [8] the frequency of extraction orthodontic treatment was 47% in class III patients, and maxillary premolars were the most commonly extracted teeth (31.3%). These findings were similar to those of the present study. It appears that selection of this treatment plan can be due to the technique of surgery for this malocclusion. [24]

One strength of this study was that all patient-related risk factors that could affect the selection of extraction treatment plan such as gender, age at the time of treatment onset, overjet, overbite, space discrepancy, Curve of Spee, dental malocclusion, skeletal malocclusion, mandibular plane angle, and cross-bites were evaluated between 1994-2018. Moreover, in this study, considering the diversity of the samples, to estimate the odds of selection of orthodontic extraction treatment plan for a patient with specific characteristics, the logistic regression model was used. Employing this model showed that, all else being equal, increased crowding increased the odds of orthodontic tooth extraction.

Change in space discrepancy from negative (crowding) towards positive (spacing) decreased the odds of selection of extraction treatment plan (OR: 0.787, P=0.000). Jackson et al. [7] showed that by an increase in crowding, the odds of tooth extraction increased (OR: 1.2). Considering the small increase in odds, statistical tests showed that crowding alone was not a definite indicator of tooth extraction because when the frequency of orthodontic extraction reached its maximum level in 1960, stability was still the main concern.

By advances in orthodontics and finding that tooth extraction does not guarantee stability of the treatment results [6-10], the significance of crowding as an indicator of orthodontic tooth extraction diminished. The current esthetic demands and soft tissue support may require upright incisors in dental arch. Thus, the theory of extraction for further reduction of crowding was revised. [5, 6, 22]

The current results, similar to the findings of Jackson et al.[7] (OR: 0.8) indicated that after controlling for the effect of crowding and other risk factors in the maxilla and mandible, reduction of overbite increased the odds of tooth extraction (OR: 0.545, P=0.02). This small but statistically significant effect indicates that contemporary orthodontics is shifting to preservation of the overbite, and tooth extraction to control the vertical height is an accepted treatment in contemporary orthodontics. [17, 18]

In the anteroposterior dimension, by an increase in overjet, the odds of tooth extraction increased (OR: 1.73, P=0.036). This finding was in line with the results of Jackson et al. [7] (OR: 1.1). The odds of orthodontic extraction were higher in class II malocclusion patients (P=0.05, OR: 1.952). The same was reported by Jackson et al (OR:1.5). [7] However, class III dental and skeletal patients did not have extraction treatment plan as high as class II patients. Thus, it appears that these results suggest a change in contemporary orthodontics in use of extraction treatment to camouflage the class II rather than class III malocclusion. Proffit et al,[32] in their study in 2013 reported that the frequency of class III patients undergoing orthognathic surgery increased while the frequency of class II patients undergoing orthognathic surgery decreased in the past 10 years.

Conclusion

In total, this study indicated that the overall rate of tooth extraction in orthodontic treatment decreased by 33% in the past 25 years. The four-premolar extraction followed by the two-maxillary premolar extraction were the most commonly used protocols. Orthodontic extraction was the most common in class II malocclusion patients.

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Conflict of Interest

No Conflict of Interest Declared■

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