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The Correlation between Pain Perception among Patients with Six Different Orthodontic Archwires and the Degree of Dental Crowding

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SUMMARY

Introduction Forces generated in orthodontic treatment with fixed appliances create tension and compression zones in the periodontal ligament resulting in a painful experience for patients. In the first phase of orthodontic treatment, when leveling of teeth is needed, nickel-titanium (NiTi) archwires can be completely engaged in brackets, even in the cases of extreme crowding, exerting small forces. There is a great individual variation in the pain perception related to the application of orthodontic forces.

Objective The aim of this study was to investigate the pain perception among patients with dental crowding after insertion of six different NiTi orthodontic archwires as a part of fixed appliances in the first stage of orthodontic treatment.

Methods The study was conducted on a sample of 189 orthodontic patients receiving one of six different either superelastic or heat activated NiTi archwires, in the first phase of orthodontic treatment. Pain perception was evaluated in groups of patients with different degree of crowding. The modified McGill Pain Questionnaire with Visual Analogue Scale was used to evaluate the quality and intensity of pain. Statistical analysis was performed using simple descriptive statistics, and Pearson`s chi-square test with statistical significance of $p<0.05$.

Results Majority of patients reported pain as discomfort or pressure of moderate intensity caused by chewing or biting, started within 12 hours, carried on for 3-4 days, and decreased over time without self-medication.

Conclusion No correlation was found between pain perception among patients with different types of NiTi archwires and the degree of crowding.

Keywords: nickel-titanium archwires; pain; dental crowding; orthodontics

INTRODUCTION

The initial discomfort experienced during orthodontic treatment for the first couple of days after force application is generally accepted as inevitable. Most orthodontic appliances deliver a relatively complicated set of forces and moments that are indeterminate and not quantitatively predictable. Many factors have been assumed to affect the perception of pain, namely the intensity and duration of applied forces, age and gender, degree of crowding, structure of wires, patient's psychological background and past experiences. There is a traditional belief of the existence of a relationship between the amount of force applied to the tooth and the degree of pain experience. Existing literature has indicated that patients may feel tension, pressure, soreness of teeth, and pain as a result of orthodontic treatment [1, 2, 3]. The prevalence of experiencing at least some degree of pain among subjects ranges from 70% to 95% [4].

Nickel-titanium (NiTi) alloys have been widely used in orthodontics, especially at the beginning of orthodontic treatment. This is mainly due to their good mechanical properties, biocompatibility and ductility, resistance to corrosion, lower elastic modulus, superelasticity and shape memory effect (SMA). The superelasticity is the property of NiTi alloy to deflect on loading without plastic deformation, and return to its preformed shape after unloading. The alloy can be deformed up to 8% strain, which is useful in leveling severely misaligned teeth. Shape memory heat-activated NiTi archwires can return to their original shape, recovering from large strains throughout heating. While superelasticity is induced by stress, shape memory is initiated when the alloy in martensite phase is warmed and transformed to stable austenite phase in the specific range of temperature transformation. The deflection of heat activated alloy can generate locally stress induced martensite, which is unstable at oral temperature and undergoes reverse transformation to austenite as soon as the stress from misaligned teeth is relieved.

Wire is very pliable in the areas of crowded teeth exerting continuous force until the teeth move into a new position and reduction in deflection occurs [4-9].

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OBJECTIVE

The aim of this study was to investigate pain perception among patients with dental crowding after insertion of six different NiTi orthodontic wires in the first stage of orthodontic treatment with fixed appliances.

METHODS

The scientific protocol was approved by the Ethic Committee of the School of Dental Medicine, University of Belgrade, and all subjects signed informed consent form to participate in this study.

The investigation was conducted on a sample of 189 orthodontic patients (84 male and 105 female) treated at the Department of Orthodontics, University of Belgrade satisfying the following criteria: 12-30 years of age, permanent dentition, no systemic medical or chronic conditions, no caries and periodontal disease and no history of chronic pain, depression and anxiety. Conventional 0.018 inch slot stainless steel brackets – Ricketts prescription (Equillibrium II metal brackets, Dentaurum, Germany) were bonded. The following initial archwires (0.014 inch diameter) were randomly inserted and ligated: 1) Rematitan (Dentaurum, Germany) – superelastic archwire; 2) Sentalloy (GAC, Japan) – superelastic archwire; 3) Truflex (Ortho Technology, USA) – superelastic archwire; 4) Rematitan Thermo NiTI (Dentaurum, Germany) – heat activated archwire; 5) Truflex Thermo (Ortho Technology, USA) – heat activated archwire; 6) Damon Copper NiTi (Ormco, USA) – heat activated archwire.

At the end of bonding appointment all subjects were given the modified McGill Pain Questionnaire with Visual Analogue Scale (VAS) and asked to fill it out until the next appointment (Figure 1). The Questionnaire consisted of questions concerning the cause of pain, type, location, duration, intensity, initiation of pain perception as well as the level of self-medication.

All patients received one of six either superelastic or heat activated archwires from different manufacturers. The patients were allocated to one of six groups with the same archwire and divided in regard to the degree of dental crowding in three groups: mild crowding (less than 4 mm of space deficiency), moderate crowding (from 4-6 mm of space deficiency) and severe crowding (more than 6 mm of space deficiency) (Table 1).

Statistical analysis was performed using simple descriptive statistics and Pearson's chi-square test with statistical significance of $p<0.05$.

Table 1. Distribution of individuals with different degree of crowding

Archwires	Mild crowding		Moderate crowding		Severe crowding	
	n	%	n	%	n	%
Rematitan	4	12.90	18	58.06	9	29.03
Sentaloy	11	31.43	13	37.14	11	31.43
Truflex	6	23.08	11	42.31	9	34.62
Rematitan Thermo	12	38.71	8	25.81	11	35.48
Truflex Thermo	17	53.13	8	25.00	7	21.88
Damon	10	29.41	15	44.12	9	26.47

n – number of subjects; % – percentage of subjects

RESULTS

Mild crowding (Tables 2 and 3): The most frequently reported cause of pain (statistical significance) was chewing

Table 2. Distribution of pain parameters in patients with mild crowding and superelastic archwires

Superelastic archwire	*Rematitan* (n=4)			*Sentaloy* (n=11)			*Truflex* (n=6)		
	Parameter	%	p	Parameter	%	p	Parameter	%	p
Trigger	Rest	33	0.34	Biting	37	<0.05	Chewing	45	<0.05
Description	Discomfort/pressure	50/50	<0.05	Pressure	42	<0.05	Discomfort/pressure	20/20/20	0.52
Beginning	Immediately	50	1.00	After 6 days	60	0.20	After 6 hours	67	0.22
Duration	4 days	100	0	4 days	50	0.22	3/4 days	33/33	0.88
Intensity	4/5	50/50	1.00	4	40	0.41	2	33	0.96
Site/teeth location	Posterior teeth	50	1.00	All teeth	40	0.57	Anterior teeth	34	0.88
Medication	No	67	0.56	No	70	0.21	No	83	0.10
End of pain	Decreased	67	0.56	Decreased	60	0.53	Decreased	83	0.10

n – number of subjects; % – percentage of subjects; p – level of statistical significance

Table 3. Distribution of pain parameters in patients with mild crowding and heat activated archwires

Heat activated archwires	*Rematitan Thermo* (n=12)			*Truflex Thermo* (n=17)			*Damon* (n=10)		
	Parameter	%	p	Parameter	%	p	Parameter	%	p
Trigger	Chewing	41	<0.05	Chewing	52	<0.05	Biting	61	<0.05
Description	Sharp	42	0.07	Pressure/tingling	25/25	<0.05	Discomfort	40	0.52
Beginning	After 12 hours	55	0.18	After 6 hours	62	0.32	After 6 hours	80	<0.05
Duration	4 days	55	0.31	2 days	44	0.21	2 days	50	0.51
Intensity	7	36	0.59	4	44	<0.05	¾	30	0.74
Site/teeth location	Anterior teeth	64	<0.05	Anterior teeth	44	0.57	Anterior teeth	40	0.57
Medication	No	90	<0.05	No	88	<0.05	No	90	<0.05
End of pain	Decreased	72	0.13	Decreased	50/50	1.00	Decreased	50/50	0.10

Patient name

Age
Crowding Mild Moderate Severe
Extractions NO YES
Teeth

7 6 5 4 3 2 1	1 2 3 4 5 6 7
7 6 5 4 3 2 1	1 2 3 4 5 6 7

Date of archwire insertion
Type of archwire

PLEASE ANSWER THE FOLLOWING QUESTIONS

What was the pain trigger?
1. No pain
2. Chewing
3. Biting
4. Cold food or liquid
5. Hot food or liquid
6. At rest
7. Only during the night
8. Physical activity

Where did you perceive pain?
1. Frontal teeth
2. Posterior teeth
3. All teeth
4. Upper jaw
5. Lower jaw
6. Head

Describe the pain:
1. Discomfort
2. Pressure
3. Tingling
4. Dull
5. Sharp
6. Pulsating
7. Headache

On the scale from 0 to 10 (0 – no pain; 10 – the strongest pain you have ever experienced) please mark the pain you perceived after archwire insertion.

0 1 2 3 4 5 6 7 8 9 10

When did the pain start?
1. Immediately after insertion of an archwire
2. 6 hours later
3. 12 hours later
4. Two days later
5. More than two days later

Duration of pain
- 1 day
- 2 days
- 3 days
- 4 days
- Longer

Has the intensity of pain decreased over time? **YES** **NO**
Have you taken any pain medication? **YES** **NO**

Figure 1. Modified McGill Pain Questionnaire (MPQ) with Visual Analogue Scale (VAS)

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Table 4. Distribution of pain parameters in patients with moderate crowding and superelastic archwires

Superelastic archwires	*Rematitan* (n=18)			*Sentaloy* (n=13)			*Truflex* (n=11)		
	Parameter	%	p	Parameter	%	p	Parameter	%	p
Trigger	Biting	38	<0.05	Biting	33	<0.05	Chewing	33	0.06
Description	Pressure	35	<0.05	Pressure	37	<0.05	Pressure	50	<0.05
Beginning	After 12 hours	39	0.29	After 6 hours	50	0.17	Immediately	40	0.90
Duration	4 days	33	0.49	2 days	50	0.11	4 days	38	0.27
Intensity	3	22	0.86	8	42	<0.05	5	30	0.86
Site/teeth location	All teeth	44	0.89	Upper jaw	58	<0.05	All teeth	63	0.36
Medication	No	75	<0.05	Yes	69	0.17	No	60	0.53
End of pain	Decreased	83	<0.05	Decreased	54	0.78	Decreased	78	0.09

Table 5. Distribution of pain parameters in patients with moderate crowding and heat activated archwires

Heat activated archwires	*Rematitan Thermo* (n=8)			*Truflex Thermo* (n=8)			*Damon* (n=15)		
	Parameter	%	p	Parameter	%	p	Parameter	%	p
Trigger	Biting	36	0.08	Rest	39	<0.05	Rest	33	<0.05
Description	Pressure	20	0.79	Pressure	43	<0.05	Pressure	38	<0.05
Beginning	After 12 hours	57	0.37	After 12 hours	50	0.60	Immediately	40	0.27
Duration	4 days	29	0.93	4 days	38	0.88	3 days	40	0.51
Intensity	6	29	0.98	7	25	0.99	7	33	0.37
Site/teeth location	Upper jaw	43	0.67	All teeth	75	<0.05	All teeth	47	0.18
Medication	Yes	57	0.70	No	50	1.00	No	60	0.44
End of pain	Decreased	57	0.70	Decreased	63	0.48	Decreased	87	<0.05

Table 6. Distribution of pain parameters in patients with severe crowding and superelastic archwires

Superelastic archwires	*Rematitan* (n=9)			*Sentaloy* (n=11)			*Truflex* (n=9)		
	Parameter	%	p	Parameter	%	p	Parameter	%	p
Trigger	Chewing	62	<0.05	Chewing	58	<0.05	Chewing	33	0.08
Description	Pressure	36	<0.05	Pressure	38	<0.05	Pulsating	30	0.05
Beginning	After 6 hours	56	0.26	After 6 hours	72	0.13	After 6 hours	50	0.42
Duration	4 days	67	0.09	4 days	37	0.63	4 days	88	<0.05
Intensity	4	33	0.80	4	27	0.76	7	50	0.39
Site/teeth location	All teeth	44	0.39	All teeth	27	0.70	Anterior teeth	63	0.19
Medication	No	78	0.09	No	72	0.13	No	50	1.00
End of pain	Decreased	75	0.16	Decreased	72	0.13	Decreased	50	1.00

Table 7. Distribution of pain parameters in patients with severe crowding and heat activated archwires

Heat activated archwires	*Rematitan Thermo* (n=11)			*Truflex Thermo* (n=7)			*Damon* (n=9)		
	Parameter	%	p	Parameter	%	p	Parameter	**%**	*p*
Trigger	Chewing	47	<0.05	Chewing	33	0.36	Chewing	50	<0.05
Description	Pressure	29	<0.05	Discomfort	38	0.17	Discomfort	40	0.09
Beginning	Immediately	55	0.18	Immediately	86	0.06	Immediately/ after 6 hours	33/33	0.75
Duration	3 days	36	0.80	2 days	43	0.67	2 days	56	0.26
Intensity	3	55	0.11	3	57	0.28	3	33	0.82
Site/teeth	All teeth	45	0.29	Anterior teeth	28	0.93	Anterior teeth	38	0.74
Medication	No	63	0.37	No	86	0.06	No	89	<0.05
End of pain	Decreased	64	0.337	Decreased	57	0.70	Decreased	67	0.32

in groups with Truflex, Truflex Thermo and Rematitan Thermo wires. Pain triggered by biting with statistically significant appearance was present in groups with Damon and Sentaloy archwires. Discomfort and pressure was present in all patients with mild crowding, except in subjects with Rematitan Thermo wire who reported sharp pain. Pain started immediately only in the group with Rematitan arcwire, whereas other groups of patients perceived pain after 6-12 hours of bonding appointment. Intensity of pain diversified between 2-7 on VAS. Subjects usually perceived pain as a discomfort in anterior teeth which decreased in 2-4 days with no pain medication taken.

Moderate crowding (Tables 4 and 5): After ligation of archwire, pain in most of the patients was provoked either by chewing or biting, with exception to patients with Truflex Thermo and Damon archwire who perceived constant pain. All subjects perceived pain as pressure initiated right after insertion of wire or with delay of 6-12 hours. Discomfort with intensity ranging from 3-8 on VAS lasted 4 days

except in patients with Damon wire who were relieved after 3 days.

Severe crowding (Tables 6 and 7): Chewing was the dominant cause of pain in patients with all 6 archwires, with statistical significance in patients with Rematitan, Sentaloy, Rematitan Thermo and Damon archwire. Pain was perceived significantly as pressure and discomfort in groups with Rematitan, Sentaloy and Rematitan Thermo archwires. No statistical significance was found in reported site of pain as well as in intensity, which was 3-4 on VAS. Only subjects in the group with Truflex Thermo archwire perceived pain as pulsating and very strong (intensity 7). Most of the time, subjects did not take any medication for pain that decreased with time.

Generally, the majority of patients reported pain of moderate intensity that was triggered by biting or chewing and started within 12 hours after bonding appointment with no relationship to crowding. The types of pain, most commonly described by subjects, were pressure and discomfort that lasted 3-4 days and decreased in intensity over time without self-medication.

DISCUSSION

The present study was performed on a sample of 189 orthodontic patients who were given the modified McGill Pain Questionnaire with VAS to assess the quality and intensity of pain after insertion of initial NiTi orthodontic wire as a part of fixed appliances. It is well-known that correct measurement of pain is an essential part of its evaluation, and adaptation of methods to control it.

Various approaches have been used to measure and evaluate pain perception in orthodontic patients. The methods adopted vary from traditional surveys with pretested questionnaires to rating with Visual Analogue Scale (VAS) [10], McGill Pain Questionnaire (MPQ) [11], and Verbal Rating Scale (VRS) [12]. None of the proposed approaches on its own have provided a precise pain assessment in orthodontics and a miscommunication and poor management of pain in orthodontic patients were reported [13]. For that matter, the modified McGill questionnaire with VAS for orthodontic purposes was proposed in this study. The questionnaire included all aspects of pain quality such as: type of pain, timing, duration, location and intensity as well as necessity for pain management. The questionnaire was found to be accurate, appropriate and clear even to younger subjects who completely understood all questions.

Following insertion and ligation of six different NiTi wires subjects perceived pain. The mechanisms by which pain arises when orthodontic force is applied are not completely understood. It has been suggested that pain perceptions are due to blood flow changes in the periodontal ligament (PDL) [14, 15]. Other studies have indicated the presence of prostaglandins, substance P, and other substances to be associated with discomfort. Two types of pain have been described in the past literature including the immediate and delayed pain responses to orthodontic treatment [16, 17]. Immediate response can be explained by the initial compression of the PDL. The delayed response is due to the partial compression of the PDL that still allows blood flow and over time results in hyperalgesia of the PDL which lowers the patient's pain tolerance. This type of pain develops a few hours after appliance placement and is caused by an increased sensitivity to prostaglandins, histamines, and substance P [18].

It has been previously reported that the magnitude of the force applied to teeth corresponds to the experienced pain [4, 19]. Therefore, the use of lighter forces has been recommended to reduce pain. However, other studies have found no relationship between the applied force and associated pain [20-23], and the controversy on whether or not light forces will decrease the degree of pain during tooth movement remains unanswered.

In the present study, 0.014 inch diameter wires were used for leveling in the first phase of orthodontic treatment in order to produce light forces even in cases with the most severe crowding. No differences in pain perception between patients with 0.014 and 0.016 inch NiTi archwires were found in a recent study [24]. The difference in pain response was not found when superelastic NiTi wires, conventional NiTi wires and stainless steel wires were compared [25].

A distinctive kind of force activation in superelastic and heat activated NiTi wires prompted their use in present study in order to determine if there were any differences in pain perception among patients with different wires. No statistical analysis was undertaken to compare perception of pain between patients with different types of archwire and the same degree of crowding due to a small number of subjects in each group.

In the present study, the quality and intensity of pain was not in correlation to the degree of dental crowding as well as the type of archwire. Since the pain during orthodontic treatment is mostly associated with the level of compression of the PDL, it may be hypothesized that both superelastic and heat activated NiTi archwires generate equal response of the periodontal ligament and blood vessels initiating the similar type of pain perception. Clinical and anecdotal observations have suggested a correlation between the degree of dental crowding (the intensity of forces applied by a fully engaged initial archwire) and pain. Studies revealed that the crowding at the start of treatment or the magnitude of force applied to the teeth by the archwire did not appear to affect the discomfort experienced by patients [12, 20], which was in agreement with the present study.

Two previous studies that attempted to compare pain intensities associated with application of different force magnitudes using a split-mouth design, found that higher forces were associated with stronger pain [22, 23]. In places where superelastic wire was engaged in the brackets of severely misaligned teeth, the wire did not follow the Hooke's low and exerted the same amount of force (stress) independent of the degree of activation (strain) [26]. Thus, it was expected that the amount of force applied to teeth would be the same no matter of the degree of crowding.

Results of the present study indicated that there were no significant differences in pain response in subjects with a different degree of crowding. Heat activated archwires undergo phase transformation at oral temperature. In the mouth, the wire is in austenite phase. In case of crowding teeth, stress is applied to wire and stress induced martensite is formed. Stress induced martensite is unstable at oral temperature and could be easily transformed into austenite when teeth change their position and stress is relieved. The amount of strain in the wire ligated in the slots of brackets of irregular teeth, again, is not the same as the amount of forces that wire applies to teeth. Therefore, the same amount of force was expected to be applied to teeth in mild and severe crowding [7]. Another explanation to similar pain perception in the patients with different degree of crowding would be that the force generated in the archwire is not the same (i.e. the force is higher in severe crowding), but the response from the PDL was the same if necrosis and hyalinization did not occur. Another study reported that the same degree of forces caused variations in blood flow in the PDL [27]. The authors questioned the validity of using the degree of force and pain response as a guide to the determination of the amount of hyalinization and damage to the PDL. Even if higher degree of deflection of archwire engaged in the brackets of misaligned teeth produces higher force to the PDL, the perception of pain is the same which is in agreement with the results of the present study.

The pain triggered by chewing and biting was most frequently reported by the patients. These results were consistent with findings of other studies that assessed the perception of pain during orthodontic treatment [3, 4, 12, 15, 28]. In the current investigation, the patients reported pain immediately after insertion of archwire or within the next 6-12 hours with tendency to decrease. These findings were in agreement with previous studies in which pain increased and peaked between 4 and 24 hours after the application of force and then decreased [1, 3, 12, 24, 29]. The majority of patients from various studies reported pain as pressure or discomfort that lasted for 7 days with a gradual decrease which is in agreement with the present study [1, 3, 4, 30].

CONCLUSION

The patients of all six groups with different archwires and degrees of crowding had reported a similar perception of pain at the beginning of orthodontic treatment with fixed appliances. The pain perceived as pressure or discomfort was predominantly triggered by biting or chewing, started within 12 hours of archwire insertion, lasted up to 4 days with moderate intensity and decreased over time without self- medication. In an attempt to describe if the degree of crowding was associated with different pain perception no significant correlation was found. Information obtained from the questionnaire can help practitioners in patients' education of the quality and intensity of expected pain as well as adequate pain management.

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Зависност између перцепције бола код пацијената са шест различитих ортодонтских жица и тескобе зубних низова

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КРАТАК САДРЖАЈ

Увод Ортодонтске силе којима се током терапије фиксним апаратима померају зуби доводе до истезања и компресије пародонталних влакана, те појаве бола код пацијената. У првој фази ортодонтског лечења, када се зуби нивелишу, жице од легуре никл-титанијума производе релативно малу силу и могу се потпуно лигирати у слотове бравица, чак и у случајевима велике тескобе. Постоје веома велике индивидуалне варијације у перцепцији бола приликом примене ортодонтских сила.

Циљ рада Циљ истраживања је био да се испита перцепција бола код особа с тескобом у зубним низовима након лигирања шест различитих ортодонтских жица у склопу прве фазе терапије фиксним апаратима.

Методе рада Студија је урађена на узорку од 189 пацијената којима је у оквиру ортодонтског лечења фиксним апаратима била лигирана једна од шест различитих суперелластичних или термо жица од легуре никл-титанијума. Перцепција бола је процењивана код особа с различитом израженошћу тескобе. Коришћен је модификовани Макгилов (*McGill*) упитник за бол с Визуелном аналогном скалом ради описивања квалитета и интензитета бола. Статистичка обрада података је обухватила дескриптивну статистичку анализу и примену χ^2-теста са статистичком значајношћу од $p<0,05$.

Резултати Највећи број испитаника је описао бол као непријатност или притисак средњег интензитета изазван жвакањем или додиром, који је почињао до 12 сати од лигирања жице, трајао је три-четири дана и смањивао се без примене лекова.

Закључак Није утврђена статистички значајна разлика у перцепцији бола код особа с различитом израженошћу тескобе зубних низова којима су биле лигиране супереластичне и термо жице од легуре никл-титанијума.

Кључне речи: легура никл-титанијума; бол; тескоба; ортодонција

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