

RESEARCH ARTICLE

Clinicians' Choices in Selecting Orthodontic Archwires

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Objective: The aim of this study was to assess the choices made by clinicians in selecting archwires during the initial, intermediate and final stages of orthodontic treatment with fixed appliances.

Methods: We carried out a questionnaire-based study at the Orthodontics and Paedodontics Clinic Tîrgu Mureş, between March 2012 and September 2012. The questionnaires consisted of two parts: the first included questions related to the dimension, alloy used in fabrication, section (round or rectangular) and manufacturer of the archwires used by the orthodontists in their orthodontic practice, the second part was concerned with their personal opinion about the physical properties and disadvantages of the archwires.

Results: From a total number of 90 distributed questionnaires, 62 were returned. The majority of clinicians are using stainless steel (SS) and nickel-titanium alloy (NiTi) wires in their fixed orthodontic treatments, very few are using beta-titanium (Beta Ti), copper nickel-titanium (Co-NiTi) and esthetic archwires. The preferred dimension seem to be 0.022 inches in the appliance system. Regarding the wire dimensions, 0.014, 0.016 inch wires are mostly used from the round section group and 0.016 × 0.022 inch, 0.017 × 0.025 inch from the rectangular ones.

Conclusions: There is a general lack of agreement between the clinicians surveyed regarding the properties of an ideal archwire and the disadvantages of the used wires. The most frequently used alloys seemed to be the SS and NiTi.

Keywords: archwire, orthodontics, nickel-titanium, stainless-steel

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Introduction

In recent years, the materials used by orthodontists have changed rapidly. Every day manufacturers are introducing new types of orthodontic archwires, from new alloys to esthetic, non-metallic materials, therefore the clinicians are overwhelmed by the amount of possibilities available on the market [1]. The choice of an orthodontic archwire should be based on the estimated forces produced and, from a biomechanical point of view, the forces should be continuous and low, in order to prevent root damages and patient discomfort [2]. Also, several properties and characteristics should be considered in the archwire selection of different treatment stages, among them: resilience, springback, friction, formability, biocompatibility and esthetics. But, because there is no ideal archwire, the best outcome is obtained by using a specific archwire for a specific treatment stage [3].

Traditionally, three archwire alloys are commonly used by orthodontists in their treatment stages: stainless steel (SS), nickel-titanium (NiTi) and beta-titanium (Beta-Ti). The SS alloys are considered as a reference material for comparing the characteristics of other types of orthodontic wires such as Ni-Ti and they are indicated in the treatment phases when more rigid and less springback properties are needed [4–7]. The two major properties of the NiTi wires

are their shape memory and superelasticity, which made the NiTi wire the preferred material for orthodontic applications, in which a long range of activation with constant force is needed. Ormco (Ormco Corporation, California, USA) recently introduced the Copper Ni-Ti archwire which has smaller loading forces and it is more resistant to permanent deformation.

The Beta-Ti archwires are relatively recently introduced and they have few advantages, such as: elastic modulus below SS and excellent formability. They contain both Ti and Mo and the lack of Ni in their composition allows a low potential for hypersensitivity [8–10].

With the introduction of stainless steel, the precious metal alloys are not routinely used anymore for orthodontic purposes, although their excellent biocompatibility recommends them for hypersensitive and allergic patients [2,11,12].

A new 'finishing wire' made from a nickel free Titanium–Niobium alloy (Ti-Nb) was also introduced. According to the manufacturer, Ti-Nb is soft and easy to form, yet it has the same working range as stainless steel. Total control during detailing makes Ti-Nb the wire of choice during the final treatment phase [3].

With the increasing demands of adult patients for esthetics, a large number of non-metallic archwires were developed. Clear optical fiber and composite wires have excellent esthetics and strength, as well as the ability to customize their properties to the needs of the orthodontists.

These are considered the future of orthodontics and they are likely to replace the classic metallic wires in the next years [3,13–15].

The aim of this research was to assess clinicians' views regarding the choice of archwire during the initial, intermediate and final stages of orthodontic treatment with fixed appliances and the use of newly introduced wires. Their personal opinion about the physical properties and disadvantages of the archwires were also investigated, in order to compare it with their practice when selecting working wires.

Materials and methods

We carried out a questionnaire-based study at the Orthodontics and Pedodontics Clinic of Tîrgu Mureş, Romania, between March 2012 and September 2012. A total number of 90 questionnaires were personally handed to clinicians at local meetings and courses within the dental hospital. The clinicians asked to complete the questionnaires included 20 residents, 35 orthodontists: specialists for less than 5 years, and 35 orthodontists: specialists for more than 5 years.

The structured-disguised questionnaire included a total number of 11 closed-ended questions. The clinicians were asked to choose one or more of the options given. The questionnaire is presented in Annex 1. The questionnaire was divided into 2 parts:

The first part assessed clinical practice during initial, intermediate and final stage of the fixed orthodontic therapy, with particular regard to:

1. The brackets' slot dimension currently used.
2. Archwire material choices, dimensions, section and trade name of the routinely used wires, if known.
3. If esthetic archwires are currently used.

In the second part of the questionnaire, we were interested in finding out the personal views regarding the most important mechanical properties and characteristics of the used archwires and the most frequent failures of the wires, observed clinically. The questions considered the following:

1. Number of archwires usually used during treatment time.
2. The attitude toward used archwires, if they are sterilized or not.
3. The properties of an ideal archwire, in the clinician's opinion.
4. The failures observed.
5. Are the used archwires' properties modified compared to the new ones?

Statistical analysis was not carried out, as it was considered that it would not be helpful in view of the large number of variables.

Results

The questionnaires were returned by 63 clinicians giving a 70.0% response rate.

Sixty-eight point 2 percent ($n = 43$) of the respondents used a 0.022 inch slot system for their fixed appliances and only 31.7% ($n = 20$) used a 0.018 inch slot system. During the initial stage of aligning and leveling phase 92.0% ($n = 58$) used only round sections of wire, while 19.0% ($n = 12$) used both round and rectangular wires. The most frequently used wire dimensions were: 0.014 inch (68.2%, $n = 43$), 0.016 inch (61.9%, $n = 39$) and 0.016 × 0.022 inch (15.8%, $n = 10$), and the most frequently used alloy for wires was Ni-Ti (100%, $n = 63$), while only 4.76% ($n = 3$) used the SS wires too. Regarding the manufacturer, 30.1% ($n = 19$) of the respondents did not know the manufacturer of the archwires and 38.0% ($n = 24$) used the GAC (GAC International TM) companies' archwires.

During the intermediate phase (space closing) 85.7% ($n = 54$) of the clinicians used only rectangular archwires, while 23.8% ($n = 15$) used both round and rectangular archwires. More than half of the clinicians, 57.1% ($n = 36$) used the 0.016 × 0.022 inch wire dimension and only 38.0% ($n = 24$) of them used the 0.017 × 0.025 inch wires during the intermediate treatment stage. The SS archwires alloy were used by 85.7% ($n = 54$) of the clinicians, the NiTi by 20.63% ($n = 13$), and only 3.1% ($n = 2$) orthodontists used the Beta-Ti alloy in this stage. The chosen manufacturer was the GAC Company (GAC International TM) in 52.3% ($n = 33$) and unknown in 33.3% ($n = 21$).

In the final stage (finishing phase) 49.2% ($n = 31$) used round wires and 60.3% ($n = 38$) used rectangular wires, so a number of 9.5% ($n = 6$) used both round and rectangular wires. The main choices for wire dimensions were 0.016 × 0.022 inch (30.1%, $n = 19$), 0.017 × 0.025 inch (28.5%, $n = 18$), 0.016 inch (25.3%, $n = 16$) and 0.018 × 0.025 inch (20.6%, $n = 13$). The SS wires were used by 77.7% ($n = 49$), the NiTi by 30.1% ($n = 19$), the Beta-Ti by 4.7% ($n = 3$) and the Co NiTi by 3.1% ($n = 2$) of the responders. Regarding the manufacturer 31.7% ($n = 20$) of the respondents did not know the manufacturer of the archwires and 58.7% ($n = 37$) used the GAC companies' (GAC International TM) archwires. Figure 1 presents the types of the archwires used by the clinicians for different stages of fixed orthodontic therapy. The esthetic archwires

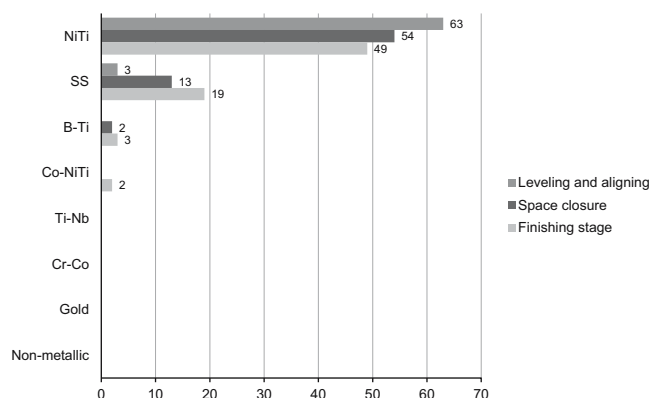


Fig. 1. Type of the archwires used by the clinicians for different stages of fixed orthodontic therapy

Table I. Properties of an ideal archwire

Options given in the questionnaire regarding the properties of an ideal archwire	Percentage of the respondents
Increased breakage resistance	42.8% (n = 27)
High resilience	14.2% (n = 9)
High flexibility	23.8% (n = 15)
Memory of the shape	47.6% (n = 30)
Low friction	49.2% (n = 31)
Low stiffness	15.8% (n = 10)
Biocompatibility	49.2% (n = 31)
Stability in oral environment	46.0% (n = 29)
Esthetic	7.9% (n = 5)
Weldability	19.0% (n = 12)
Others	0%
Don't know	7.9% (n = 5)

were currently used by 31.7% (n = 20) of the respondents.

The second part of the questionnaire returned the following results:

- Regarding the properties of an ideal archwire the results are summarized in Table I. The most important properties for the respondents seemed to be biocompatibility 49.2% (n = 31) and low friction 49.2% (n = 31), while the esthetics were less important 7.9% (n = 5).
- Unwanted bendings were the most frequent failures of the archwires observed by clinicians 53.9% (n = 34) (Table II), in contrast to allergy and mucosal lesions, observed by only 14.8% (n = 10) of the respondents.
- Also, only 20.6% (n = 13) used less than 5 archwires during the treatment, 57.1% (n = 36) used 5 archwires and 22.2% (n = 14) more than 10 archwires;
- Sixty-six point six percent (n = 42) of the orthodontists threw away the used archwires, 23.8% (n = 15) kept them in the record, while 14.2% (n = 9) sterilized and reused them at the same patient.
- Eighty-two point fifty-three percent (n = 52) of the orthodontists thought that the archwires' properties are modified after clinical use and only 17.46% (n = 11) did not know.

Discussions

The questionnaire used in the present study was designed to assess the clinicians' theoretical views concerning archwire properties and characteristics, both in the early stages of treatment, when light and flexible wires would be expected to be used, and also during intermediate phases when stiffer, larger dimension wires might be expected to be used.

The preferred slot size was the 0.022 inch by the 68.2% (n = 43) of the respondents. This finding is in accordance to a previous survey made by McNamara *et al.* [12], in which 99% of the respondents used a 0.022 inch slot system for labially placed pre-adjusted edgewise fixed appliances. In the same survey [12], the most frequently used alloy for the aligning and leveling stage was Niti. We also found that the

Table II. The observed failures of archwires

Options given by the questionnaire regarding the most frequent failures observed by the clinicians	Percentage of the respondents
Wire breakage	22.2% (n = 14)
Increased plaque retention	23.8% (n = 15)
Unwanted bendings	53.9% (n = 34)
Sliding from bracket slots	25.3% (n = 16)
Allergy and mucosal and gingival lesions	14.8% (n = 10)
Others	11.1% (n = 7)

majority of orthodontists are using round and rectangular NiTi wires in the leveling and aligning stage of their treatments, only a few are additionally using SS archwires. This shows that the percentage of clinicians using Niti archwires is constantly increasing, probably because due to the introduction of super-elastic and thermo elastic NiTi archwires, these wires are used when light forces are needed and the clinicians are able to insert larger dimension rectangular wires from the initial treatment phases [16–19].

The use of rectangular SS archwires in the space closure phase of treatment is perfectly justified, especially due to their high stiffness and strength, characteristics which offer more arch stability and torque control [9,11,17]. Beta-Ti archwires are also used in this stage of treatment, although due to their main drawback, the extremely high coefficient of friction, the sliding of teeth is limited [8]. The combination of high formability and low stiffness of beta titanium wires is considerably smaller compared to SS, so these wires are the next logical step in wire progression after initial leveling with NiTi wires [9]. Beta-Ti wires are also excellent finishing wires, especially where formability is required for large adjustments [19].

From the results, there appears to be a general agreement regarding the choice of archwire for space closure, with an almost universal use of 0.016 × 0.022 inch stainless steel wire in a 0.022 inch bracket slot. The use of the 0.022 inch bracket slot does not differ considerably from the results of the survey of American orthodontists [11], where over half (54 per cent) of the respondents used a 0.022 inch slot.

The questionnaire also highlighted differences between clinicians concerning the use of a specific wire in the finishing stage of the orthodontic treatment. Most clinicians considered stiff, rectangular SS wires ideal for the finishing stages, although some authors [2] recommend the 0.017 × 0.025 Beta-titanium in the 0.018 slot appliance and the 0.021 × 0.025 inch wires in the 0.022 slot appliance. The Co-Ni wires are recommended especially in the leveling and aligning stages, although some of the respondents use them in the final stage.

However, the differences once again highlight a general lack of agreement between the surveyed clinicians.

Interestingly, many clinicians did not know the name of the manufacturer, or the trade name of the wires they used. Others are purchasing their archwire supplies from the Gac Company (GAC International TM.)

In the second part of this study, the questionnaire concentrated on the properties and failures of archwires. Kusy [1] stated that no ideal archwire exists, because the demands of the treatment plan require different characteristics. In our survey, most of the clinicians felt that the ideal archwire should have an increased breakage resistance, shape memory, biocompatibility, low friction and stability in the oral environment. Other properties, such as resilience, flexibility, weldability and stiffness were not considered important. Several studies [1,13–16] also emphasized that the clinical performance of an archwire depends on the stiffness/strength ratio. For our respondents, esthetics is also less important and this explains the low usage rate of coated archwires.

The failures observed by the clinicians are numerous, but the most important is unwanted bends which are inconveniencing the treatment phases. The relatively high wire breakage rate (observed by 22% of the clinicians) raises questions about the corrosion of different alloys, which affects their mechanical properties. The high breakage rate and the plaque accumulation seemed to be correlated [20–23], as well as the fact that 14% of the clinicians are sterilizing and reusing the archwires. Almost all of those questioned in the present study felt that the properties of a wire after clinical use were altered. In addition, it was advocated that corrosion due to prolonged intraoral usage leads to the alteration of the mechanical properties of the archwires [21]. Differences also exist as to the number of archwires used during treatment time, McLaughlin *et al.* [24] recommend 4 to 5 archwires at a patient.

Further investigations are needed to evaluate the correlation between the mechanical properties of the used wires and the effect of the intraoral environment on these properties. Also, it is important to establish a relationship between the failure of the wires and their clinical usage characteristics.

Conclusions

1. The majority of clinicians are using the SS and NiTi wires in their fixed orthodontic treatments, very few are using Beta Ti, Copper NiTi and esthetic archwires. None of those asked is currently using the relatively new alloys such as Ti-Mo, Timolium and non-metallic archwires.
2. There was no uniformity in the bracket slot and arch dimension selection. Also, the preferred dimensions seemed to be the 0.022 inch in the used appliance. 0.014, 0.016 inch wires are likely used from the round sections and 0.016 × 0.022 inch, 0.017 × 0.025 inch from the rectangular ones.

3. There is a general lack of agreement between the clinicians surveyed relating to the properties of an ideal archwire and the disadvantages of the used wires.

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QUESTIONNAIRE

Please select your personal choice from the list below. In case your option is not listed, please specify your answer at the “other” section. Thank you for your time!

1. You are:
 - a) Postgraduate student
 - b) Orthodontist for less than 5 years
 - c) Orthodontist for more than 5 years

2. What kind of slot system are you currently using for your fixed appliances therapy?
 - a) 0.018 x 0.025 inches
 - b) 0.022 x 0.030 inches
 - c) Other

3. What kind of archwires are you using during the leveling and aligning phase?
 - *Section:*
 - a) Round
 - b) Rectangular
 - c) Twisted (multistranded)
 - *Dimension (inch):*

a) 0.012 inch	g) 0.016 x 0.022	m) 0.019 x 0.025
b) 0.014 inch	h) 0.017 x 0.017	n) 0.020 x 0.020
c) 0.016 inch	i) 0.017 x 0.025	o) 0.020 x 0.025
d) 0.018 inch	j) 0.018 x 0.018	p) 0.021 x 0.025
e) 0.020 inch	k) 0.018 x 0.018	q) 0.021 x 0.028
f) 0.016 x 0.016	l) 0.018 x 0.025	r) 0.022 x 0.028
 - *Alloy:*

a) Ni-Ti	f) Gold
b) Ti (titanium, Ni-free)	g) β -ti
c) Ti-Nb (niobium)	h) Copper Ni-Ti
d) SS	i) Nonmetallic
e) Cr-Co (elgiloy)	j) Other.....
 - *Manufacturer:*

a) Ormco	f) Ortho Organizers
b) Gac	g) G&H Wire
c) Highlands metals	h) Masel
d) Via	i) Other.....
e) OrthoTechnology	j) Don't know

4. What kind of archwires are you using during the intermediate phase (space closing)?
 - *Section:*
 - a) Round
 - b) Rectangular
 - c) Twisted (multistranded)
 - *Dimension (inch)*

a) 0.012 inch	g) 0.016 x 0.022	m) 0.019 x 0.025
b) 0.014 inch	h) 0.017 x 0.017	n) 0.020 x 0.020
c) 0.016 inch	i) 0.017 x 0.025	o) 0.020 x 0.025
d) 0.018 inch	j) 0.018 x 0.018	p) 0.021 x 0.025
e) 0.020 inch	k) 0.018 x 0.018	q) 0.021 x 0.028
f) 0.016 x 0.016	l) 0.018 x 0.025	r) 0.022 x 0.028
 - *Alloy:*

a) Ni-Ti	f) Gold
b) Ti (titanium, Ni-free)	g) β -ti
c) Ti-Nb (niobium)	h) Copper Ni-Ti
d) SS	i) Nonmetallic
e) Cr-Co (elgiloy)	j) Other.....

- **Manufacturer:**
 - a)Ormco
 - b)Gac
 - c)Highlands metals
 - d)Via
 - e)OrthoTechnology
 - f)Ortho Organizers
 - g)G&H Wire
 - h)Masel
 - i)Other.....
 - j)Don't know
5. What kind of archwires are you using during the finishing phase?
- **Section:**
 - a)Round
 - b)Rectangular
 - c)Twisted (multistranded)
 - **Dimension (inch):**

a) 0.012 inch	g) 0.016 x 0.022	m) 0.019 x 0.025
b) 0.014 inch	h) 0.017 x 0.017	n) 0.020 x 0.020
c) 0.016 inch	i) 0.017 x 0.025	o) 0.020 x 0.025
d) 0.018 inch	j) 0.018 x 0.018	p) 0.021 x 0.025
e) 0.020 inch	k) 0.018 x 0.018	q) 0.021 x 0.028
f) 0.016 x 0.016	l) 0.018 x 0.025	r) 0.022 x 0.028
 - **Alloy:**
 - a) Ni-Ti
 - b) Ti (titanium, Ni-free)
 - c) Ti-Nb(niobium)
 - d) SS
 - e) Cr-Co(cobalt)
 - f) Gold
 - g) β-ti
 - h) Copper Ni-Ti
 - i) Nonmetallic
 - j) Other.....
 - **Manufacturer:**
 - a)Ormco
 - b)Gac
 - c)Highlands metals
 - d)Via
 - e)OrthoTechnology
 - f)Ortho Organizers
 - g)G&H Wire
 - h)Masel
 - i)Other.....
 - j)Don't know
6. In your opinion, which are the properties of an ideal archwire?
- a) Increased breakage resistance
 - b) High resilience
 - c) High flexibility
 - d) Memory of the shape
 - e) Low friction
 - f) Low stiffness
 - g) Biocompatibility
 - h) Stability in oral environment
 - i) Esthetic
 - j) Weldability
 - k) Others.....
 - l) Don't know
7. Which are the most frequent wire failures observed by you, during your treatment?:
- a) Wire breakage
 - b) Increased plaque retention
 - c) Unwanted bendings
 - d) Sliding from bracket slots
 - e) Allergy and mucosal and gingival lesions
 - f) Others.....

8. How many archwires are you using during a fixed orthodontic therapy at one patient?:
 - a) Less than 5
 - b) More or equal to 5
 - c) More than 10
9. What are you doing with the removed archwires?:
 - a) I throw it away
 - b) I keep it
 - c) I sterilize and reuse it
10. Are you currently using esthetic archwires?:
 - a) Yes (please specify the manufacturer.....)
 - b) No
11. Are the properties of an archwires altered after clinical use?
 - a) Yes
 - b) No
 - c) Don't know