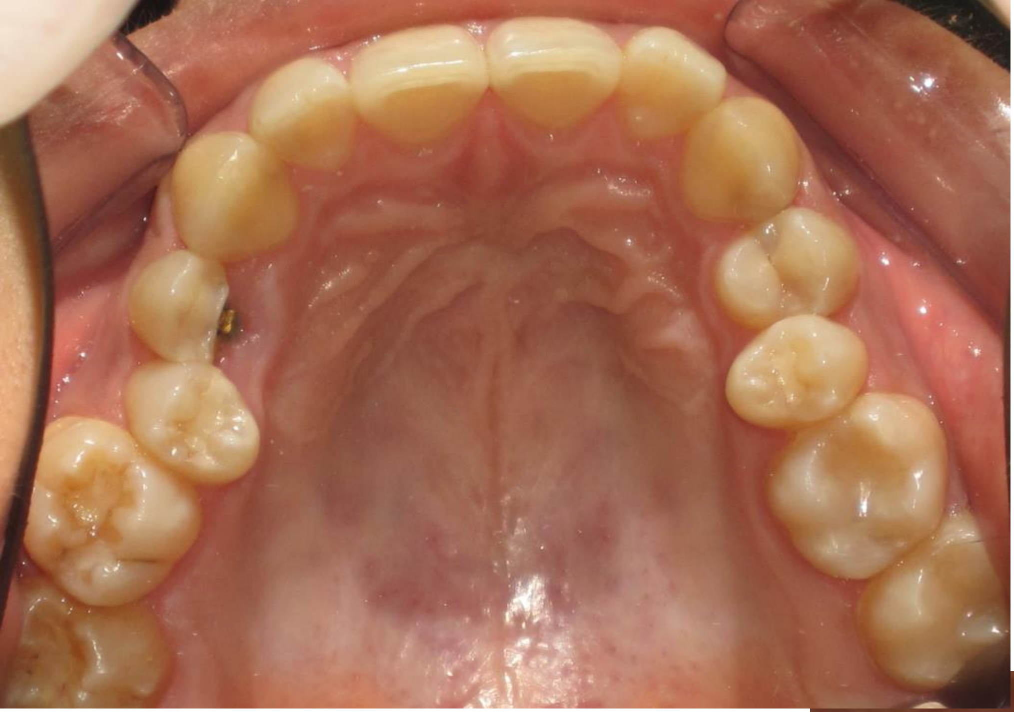
Processing, Characterization and Applications of Shape Memory Alloys Workshop

FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

Wires and brackets used in orthodontics

Rafaella Magalhães

Prof. Braz Fernandes
CENIMAT – Departamento Ciência dos Materiais – FCT/UNL



Ortodontia

Ciência que estuda as anomalias de posição e desenvolvimento dos dentes, arcadas e face, e sua influência no bem-estar físico, estético e mental do ser humano (SALZMANN, 1957).

Medicina Dentária

É a área da saúde humana que estuda e trata o sistema estomatognático (face, pescoço, cavidade bucal, ossos, músculos, articulações, dentes e tecidos)

ORTODONTIA É MODA?

Hipócrates[2] foi um dos primeiros a comentar a deformidade craniofacial:

> "Οἱ φοξοί οἱ μέν καρῖεραύχενες, ἰσχυρί καί τἆλλα καί ὀστέοισιν. οἱ δέ κεφαλαλγέες καί ὠτόρρυτοι. Τουτέοισιν ὑπερῷαι κοῖλαι καί ὀδόντες παρηλλαγμένοι."

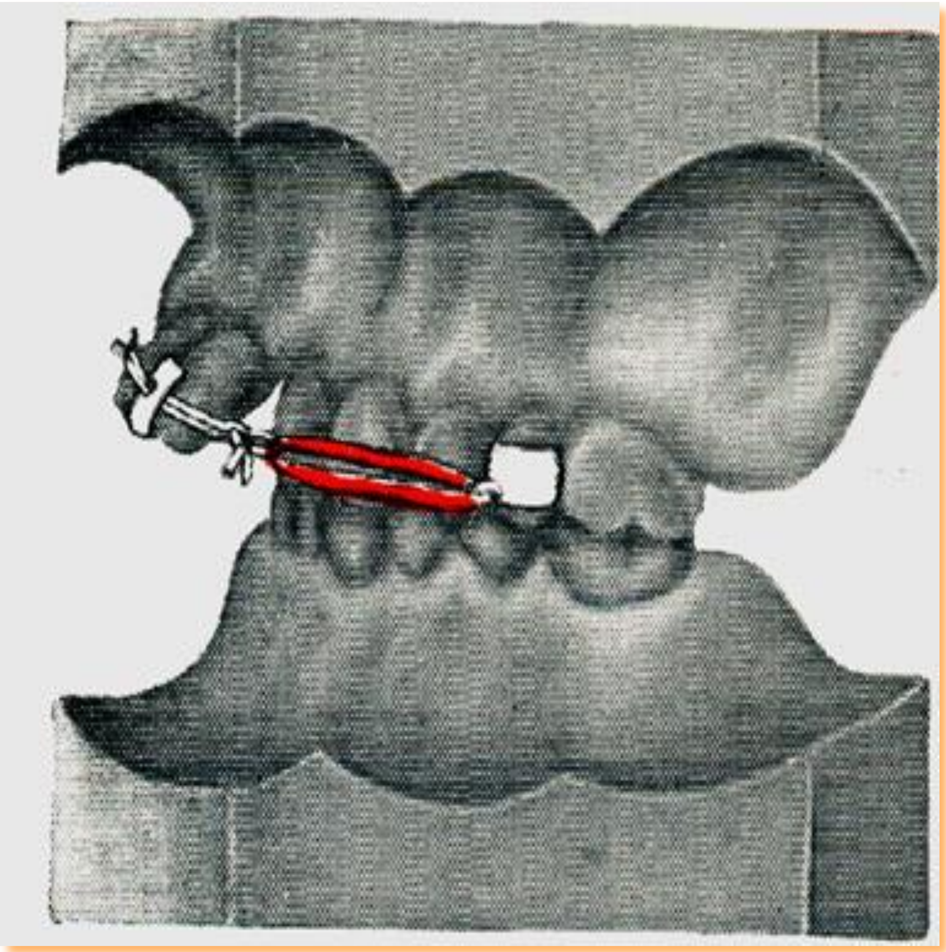
(Entre aqueles indivíduos com cabeças alongadas, alguns possuem pescoço grosso, órgão e ossos fortes. Outros têm a abóbada palatina bem arqueada, dentes irregularmente posicionados, apinhando-se uns sobre os outros; e eles são incomodados por dores de cabeça e otorréia.)

Moyers, 1991

Juan Nicolas Marjolin (1823)

Século XIX

1º – Proeminência- quando os dentes anteriores estão protruídos . Aconselhava-se extração de ambos os primeiros molares permanentes com a finalidade de distalizar os dentes através de ligaduras.



Fonte: Monti, 1942.

Por quê a maloclusão é tão prevalente?

Apesar de haver redução do tamanho dos dentes e redução no número dos dentes

REDUÇÃO DO TAMANHO DAS ARCADAS

Alteração dieta – alimentação mais processadas
Alterações genéticas?

* Cerca de 10% da população possui oclusão normal.

* Em torno de 15 a 20 % da população apresenta tipos de maloclusão severa.

* Entre estes dois extremos existe uma variedade imensa de maloclusões com graus variados de irregularidades.

O ensino da Ortodontia

Durante a lincenciatura: noções básicas

Especialização/Mestrado - diferentes escolas

Objetivo: oclusão e estética

USA

1840- 1º Curso de Medicina Dentária nos USA

1922- 1º curso de especialização Ortodontia nos EUA

BRASIL

1925- Curso de Medicina Dentária no Brasil

1958- 1º curso de Especialização Ortodontia no Brasil

EUROPA

1860- Na Inglaterra foi introduzido Surgeons Licence in Dental Surgery

1880- Sociedade Britânica

1901- 1º Curso de Medicina Dentária

1907- Sociedade Ortodontia Europa

PORTUGAL

1989 - Faculdade de Medicina Dentária da Universidade do Porto

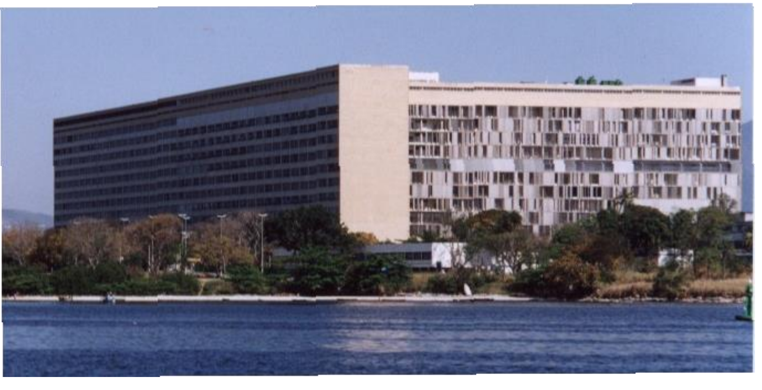
1999- Ordem dos Médicos Dentistas oficializa a especialidade de Ortodontia

Faculdade de Odontologia da Universidade Federal de Minas Gerais - UFMG -

- http://www.odonto.ufmg.br/

4ª Brasil, 13ª América Latina

1ª CAPES Programa de pós-graduação



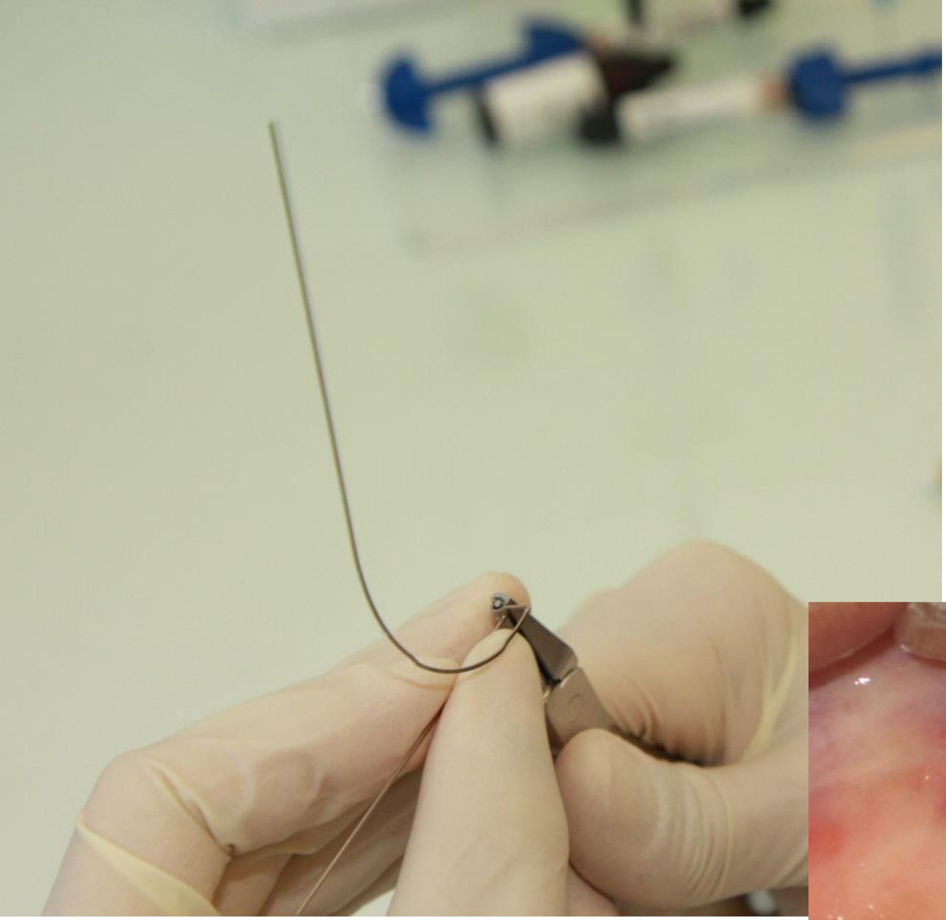
- Mestrado em Ortodontia - Faculdade de Odontologia da Universidade Federal do Rio de Janeiro - UFRJ

http://www.odontologia.ufrj.br/ortodontia/

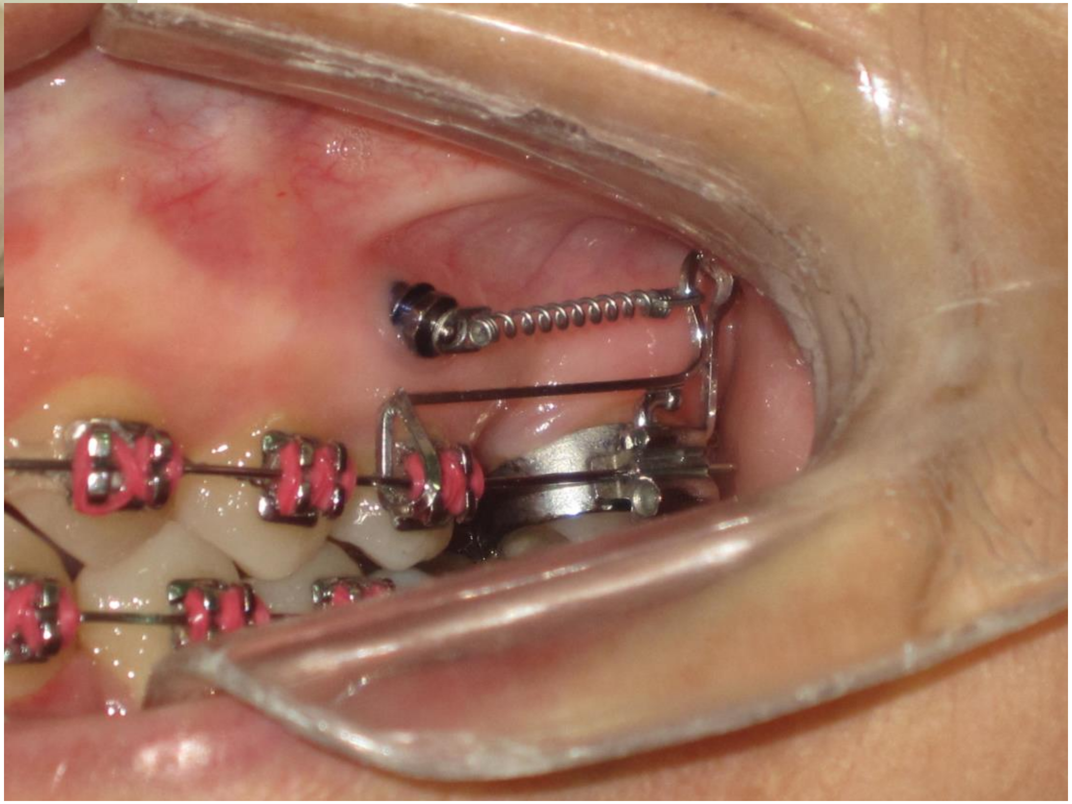
3ª Brasil, 8ª América Latina

rafaellamagalhaes@gmail.com

Ortodontista

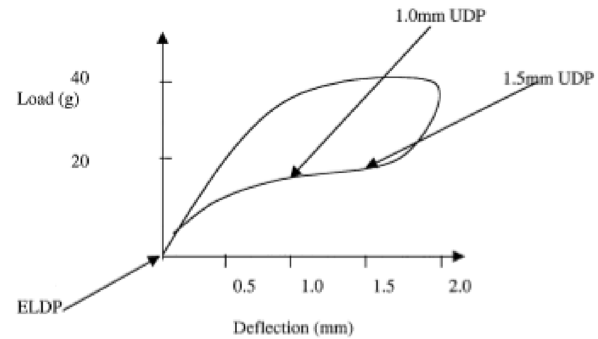


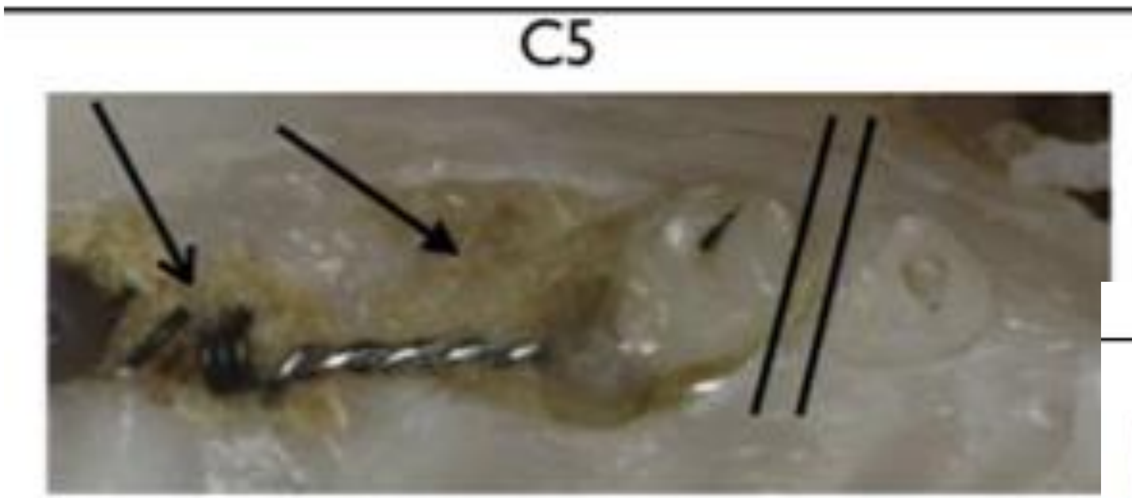
Habilidade artesão

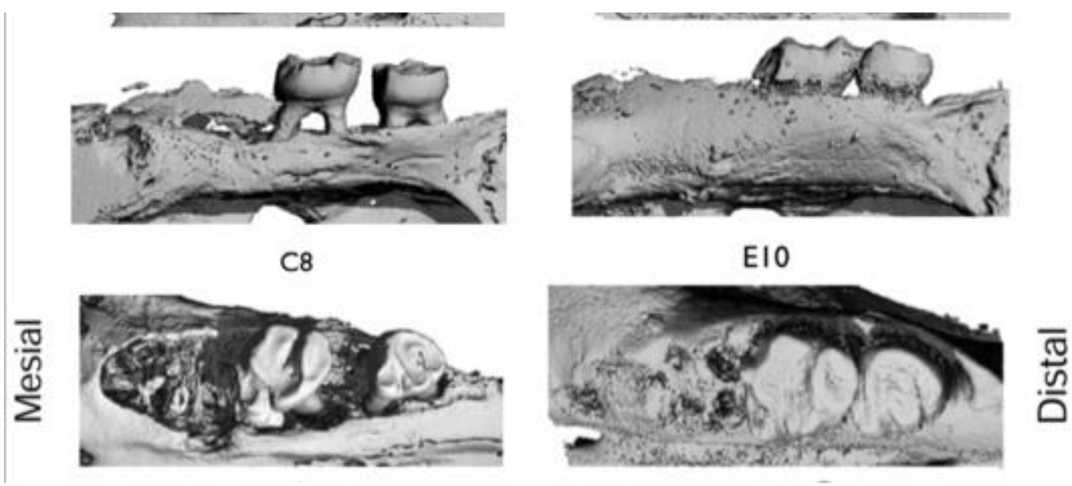


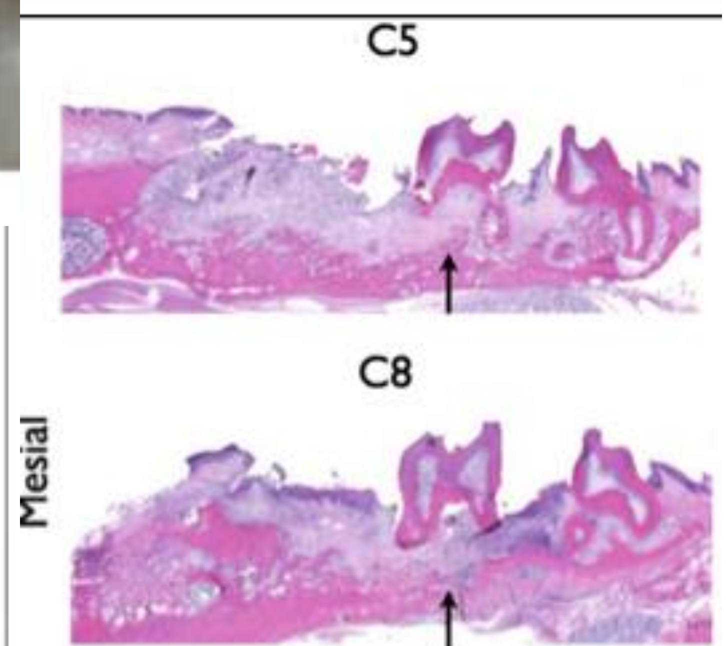
Ortodontista

Conhecimento científico









Bases biológicas da movimentação dentária

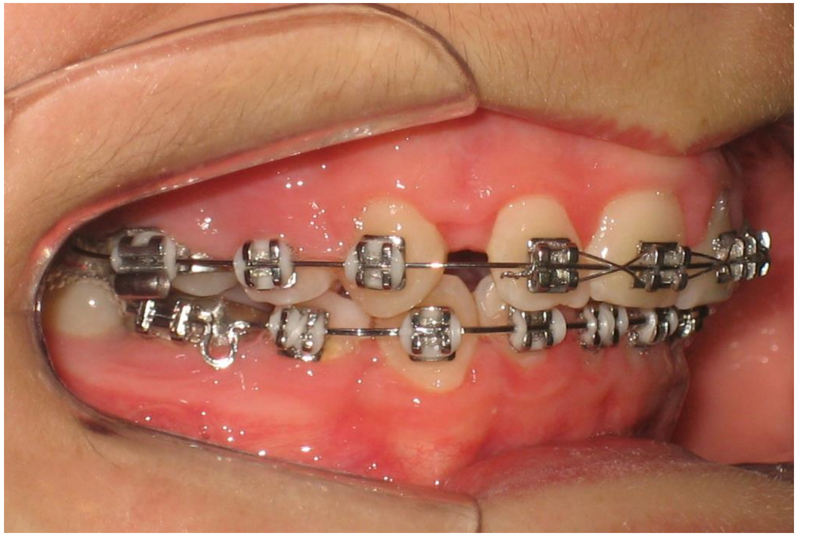
* Mudanças histológicas no ligamento periodontal

Bem definidas

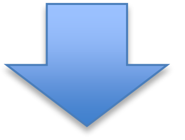
* Mecanismo celular real

Ainda não esclarecido

Bases biológicas da movimentação dentária

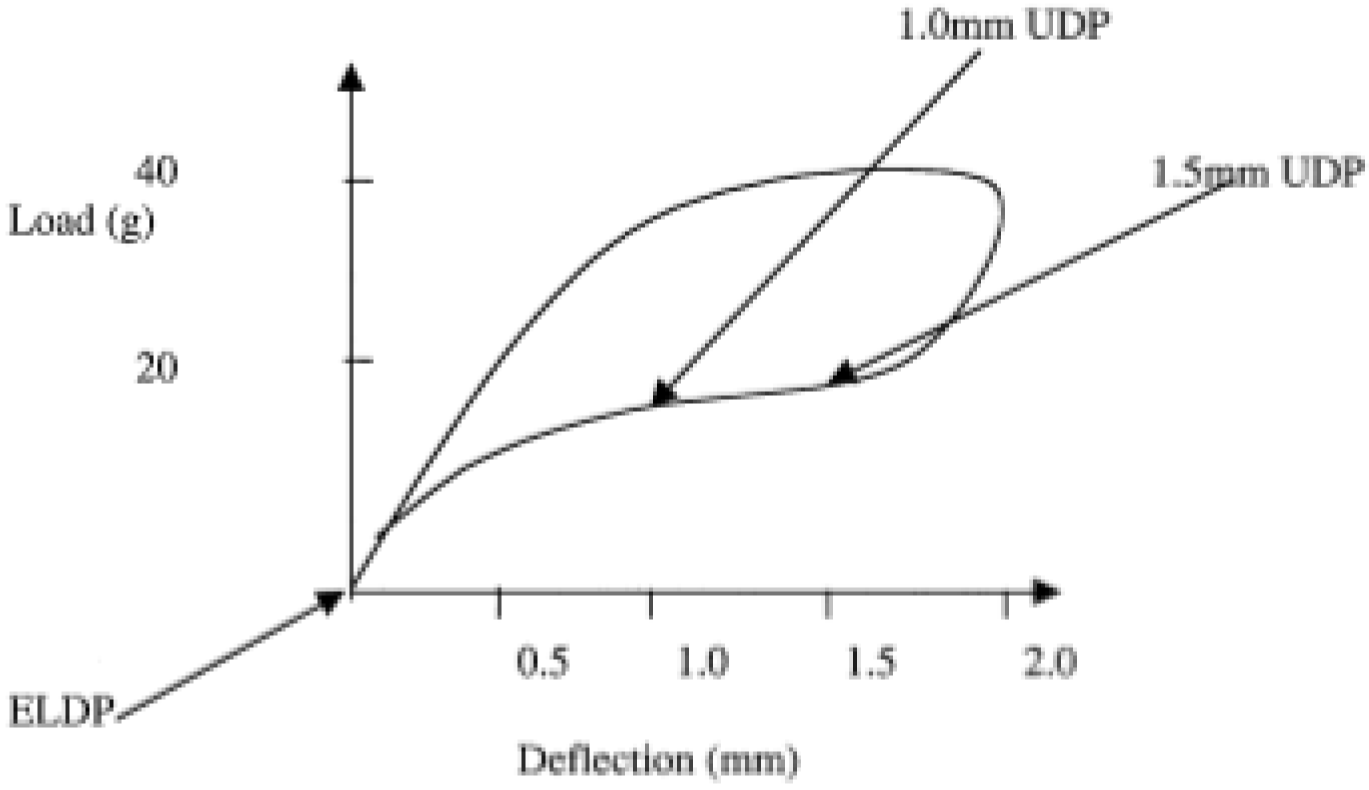


Tratamento Ortodôntico – PRESSÃO PROLONGADA APLICADA AO DENTE



Remodelação do osso ao redor do dente

ENGENHARIA



FORÇAS ÓTIMAS PARA MOVIMENTAÇÃO ORTODÔNTICA

Type of movement	Force* (gm)
Tipping	35-60
Bodily movement (translation)	70-120
Root uprighting	50-100
Rotation	35-60
Extrusion	35-60
Intrusion	10-20

*

2013

Quadro 9.3 ■ Forças Ótimas para o Movimento Dentário Ortodôntico

Tipo de movimento	*Força* (g)*
Inclinação	50-75
Movimento de corpo (translação)	100-150
Verticalização de raiz	75-125
Rotação	50-75
Extrusão	50-75
Intrusão	15-25

*Os valores dependem, em parte, do tamanho do dente; valores menores são apropriados para incisivos. Os maiores, para os posteriores multirradiculados.

1995

SE NÃO CONHECER A FORÇA IDEAL:

1) O dente pode não movimentar

2) O dente pode movimentar para o lado errado

3) Pode causar danos biológicos:

3.1 – Reabsorção radicular

3.2- Perda da vitalidade do dente

Hipócrates: *Primum non nocere*

First, do not harm.

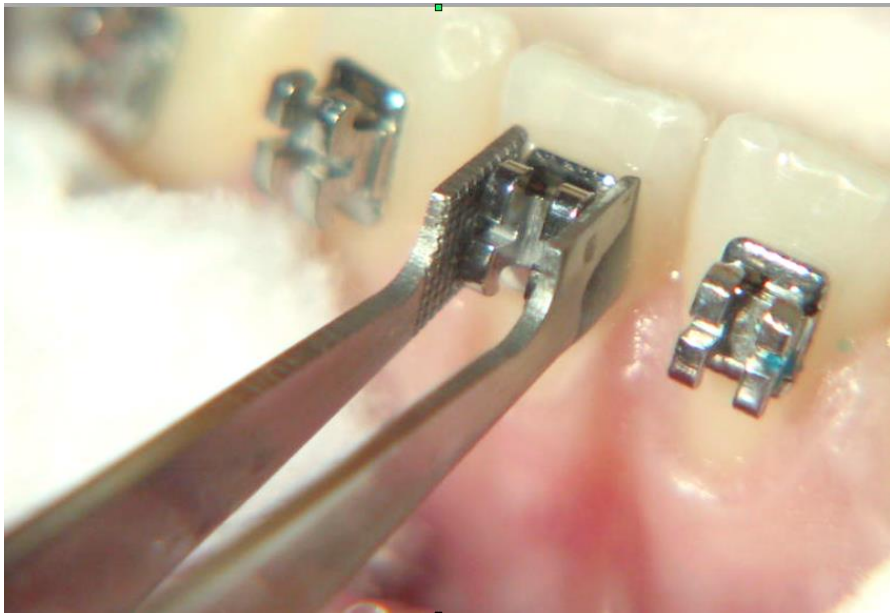
Reabsorção radicular

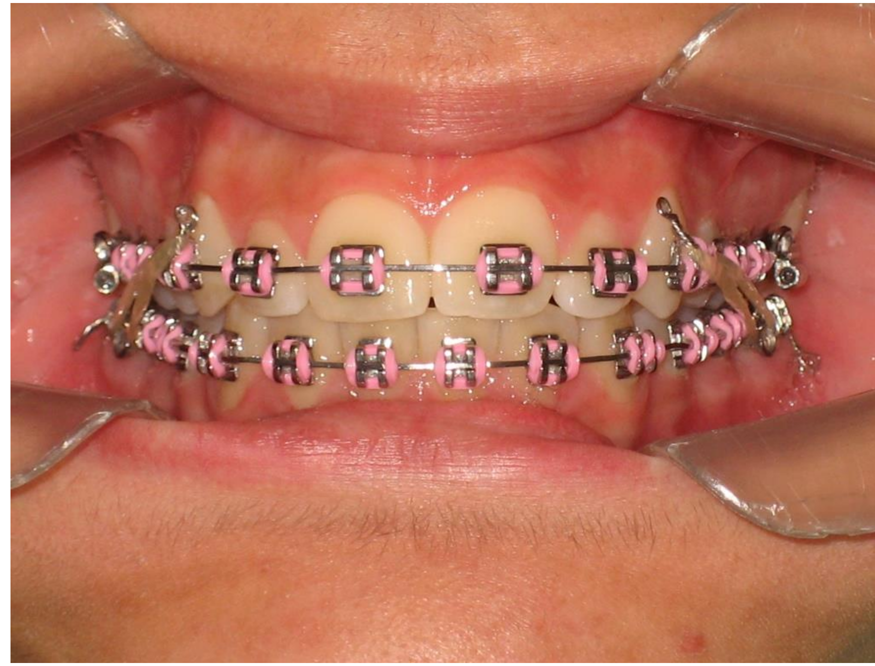
- Palavra-chave: root resorption
- Publicações na American Journal of Orthodontics and Dentofacial Orthopedics último ano

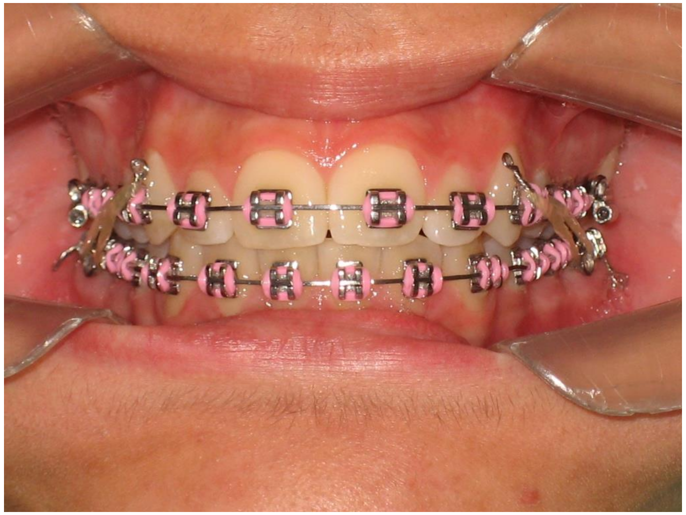
* 74 artigos

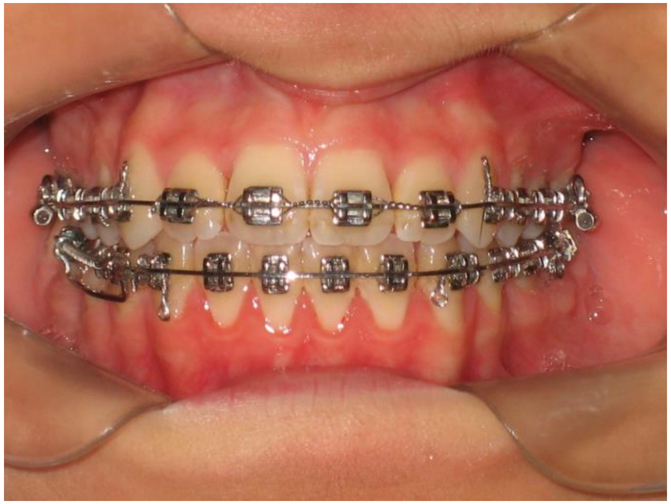
Como posicionar
melhor os dentes?

INICÍO DO TRATAMENTO: Colagem do bracket



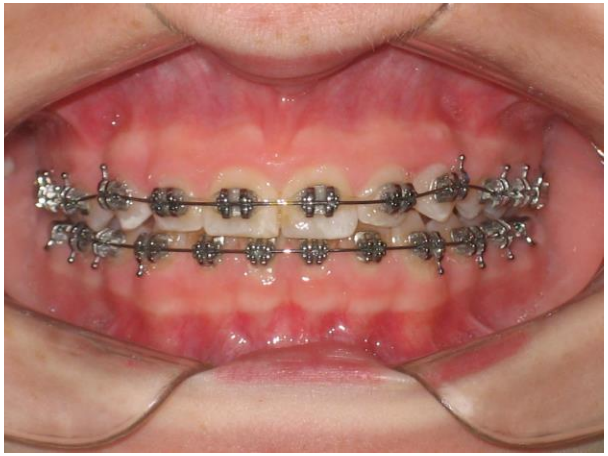






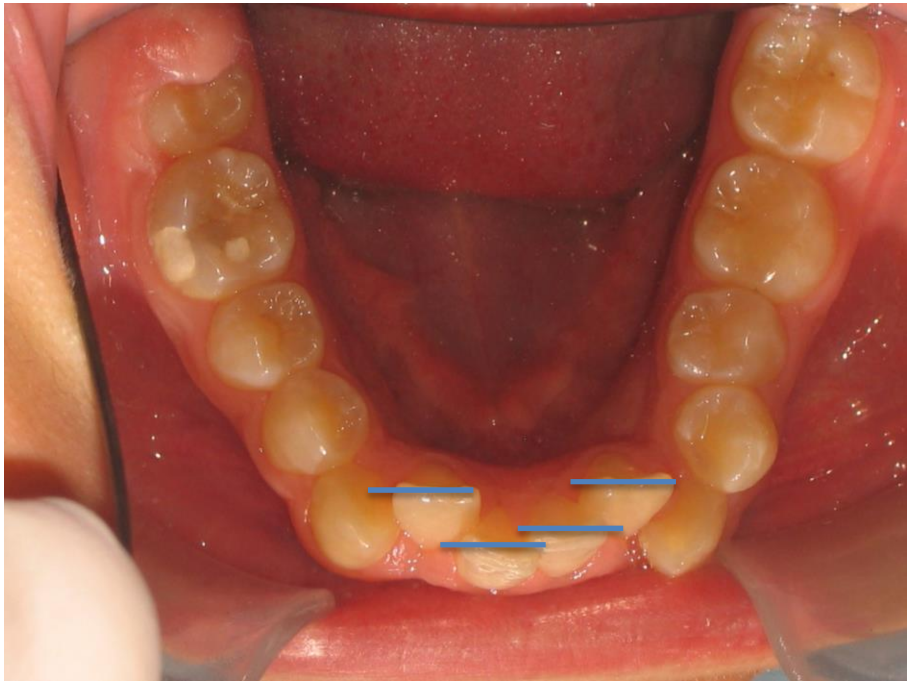
TIPO DE FIO

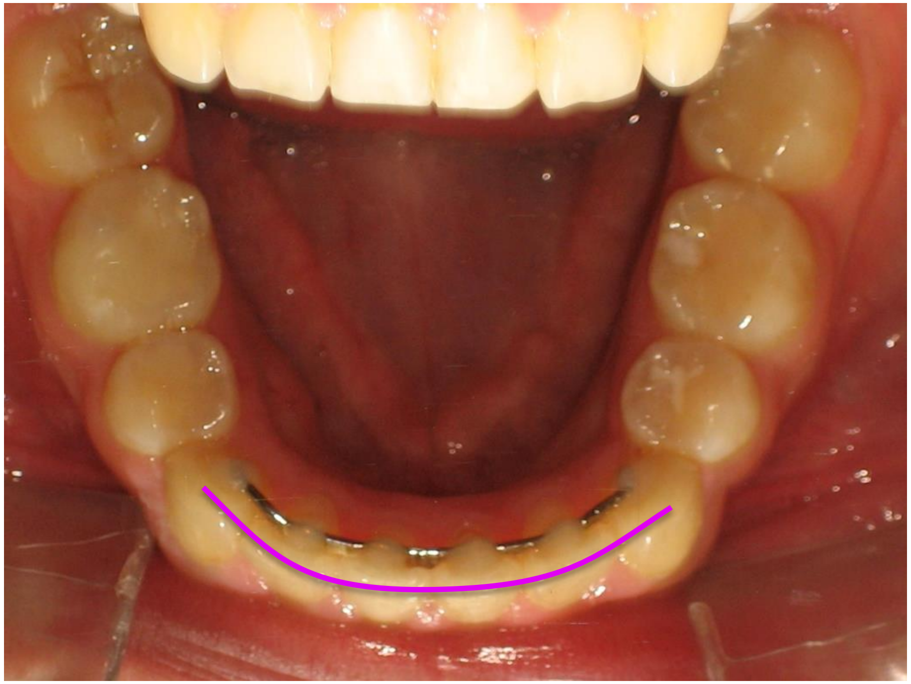
TIPO DE BRACKET



TIPO DE AMARRAÇÃO

MOVIMENTAÇÃO DOS DENTES





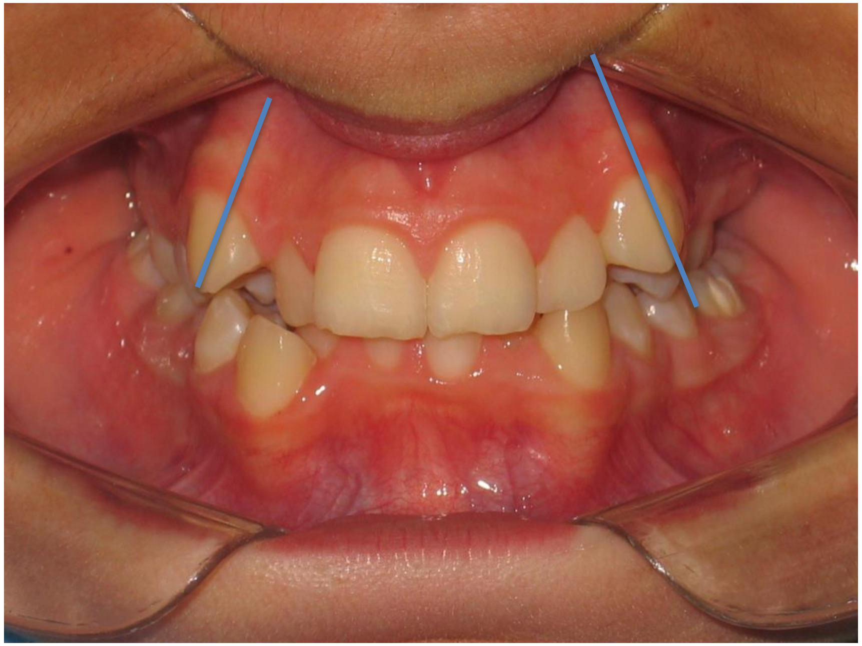
* Alinhamento - in set /off set

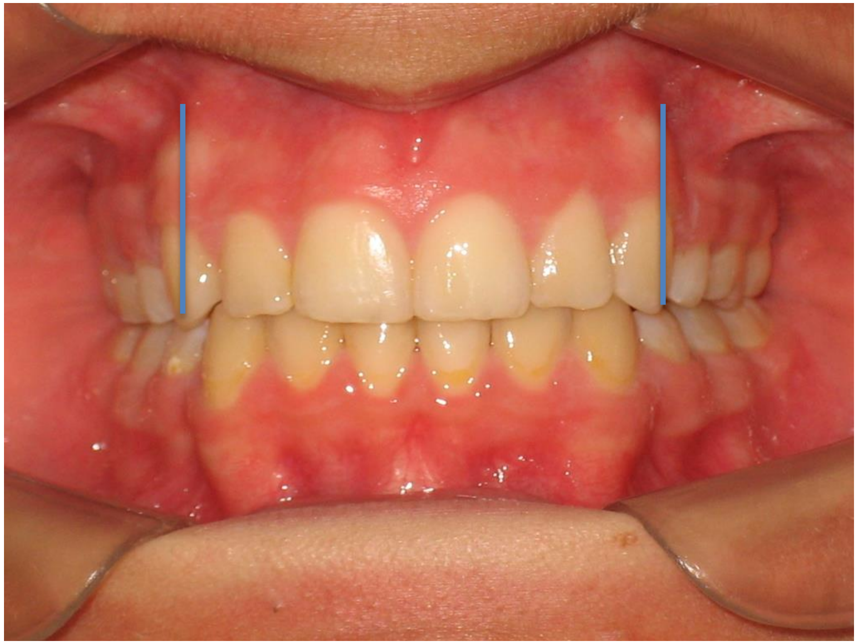
* Inclinação - tip forward/tip back

* Nivelamento - Altura - step up/step down

* Torque - vestibular/lingual ou palatino

MOVIMENTAÇÃO DOS DENTES





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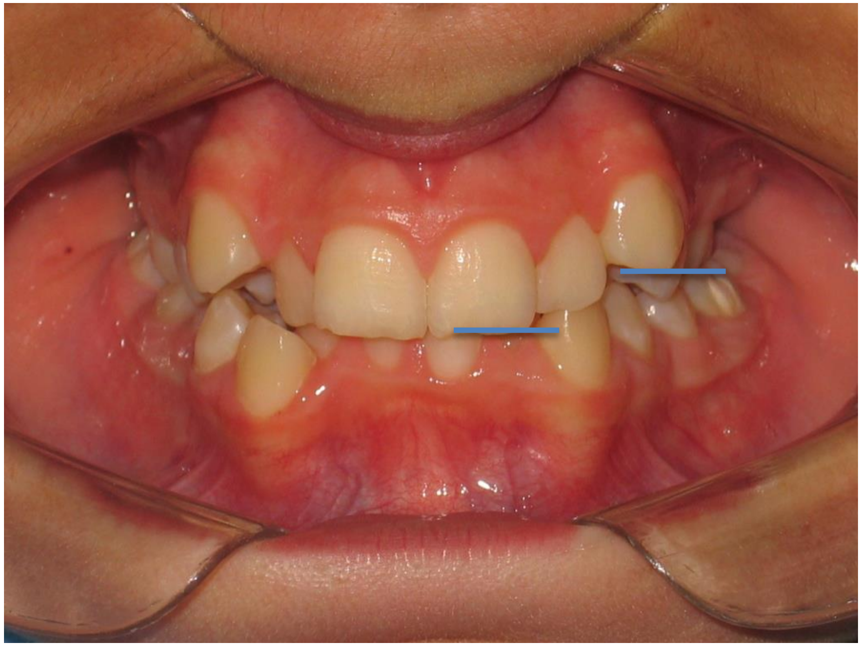
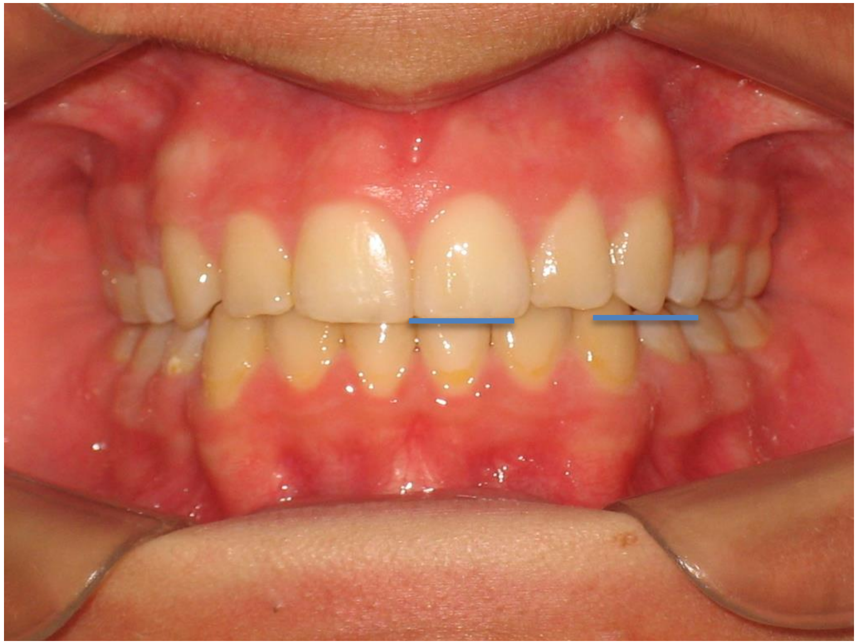
MOVIMENTAÇÃO DOS DENTES





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MOVIMENTAÇÃO DOS DENTES

* Alinhamento - in set /off set
* Inclinação - tip forward/tip back
* Nivelamento - Altura - step up/step down
* Torque - vestibular/lingual ou palatino

Material usado para brackets e fios

* Até 1929
  Ligas de níquel-prata
  Ligas de cobre, zinco e níquel
  Ligas de ouro

* 1929 – Introdução aço inoxidável

 - Empresa americana Renfert Company

 - Venda de fios produzidos pela empresa alemã Krupp

Evolução dos brackets

* Alinhamento - in set /off set
* Inclinação - tip forward/tip back
* Nivelamento - Altura - step up/step down
* Torque - vestibular/lingual ou palatino

Tipo de bracket

Metálico

1) Aço
2) Titânio

- Policarbonato

Cerâmico

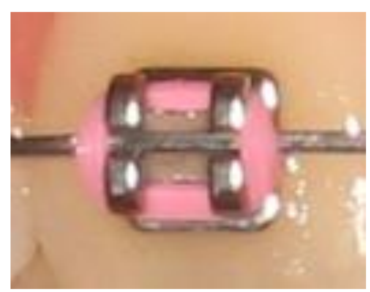
1) Com “slot” de metal

Tipo de bracket

Metálico

Standard Edgewise - o fio deve ser dobrado

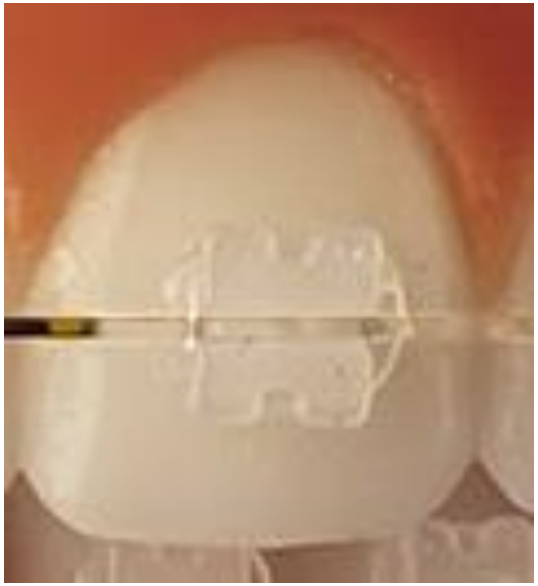
Preajusted Edgewise (“Straight wire”) as informações estão no bracket



Tipo de bracket

Cerâmico

Standard Edgewise - o fio deve ser dobrado



Preajusted Edgewise (“Straight wire”) as informações estão no bracket

A ESCOLHA DO BRACKET

1) Metálico: aço x titânio – biocompatibilidade/ alergia/custos

2) Metálico x Porcelana: estética, custos, resistência

3) Self-ligating x Amarração convencional: custos/ obtenção de resultados.

4 GRUPOS DE FIOS ORTODÔNTICOS

1) Aço inoxidável

2) Níquel- Titânio

SUPERELÁSTICOS

TERMOATIVADOS

ADICIONADOS COBRE

3) Titânio- Molibdênio (TMA)

4) Fios estéticos

1) FASE INICIAL: alinhamento e nivelamento
fios 0.012”, 0.014”, 0.016”

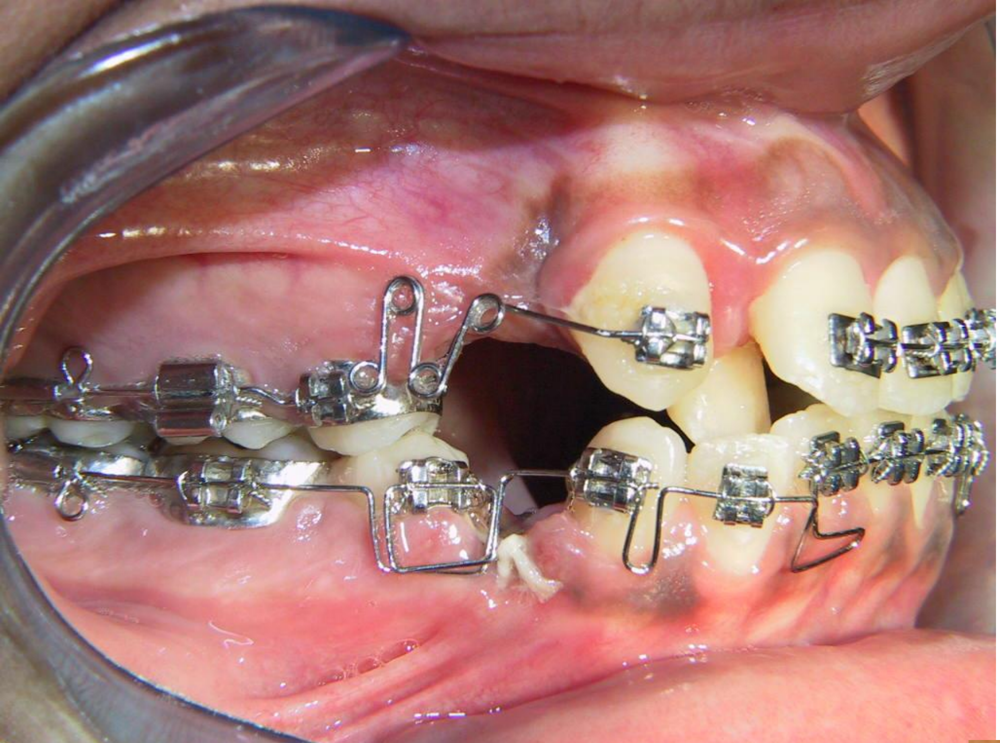
a) Niquel Titanio
b) Cu NiTi
c) Aço “trançados”

2) FASE INTERMEDIÁRIA

a) Niquel Titanio/ CuNiTI
b) TMA
c) Aço 0.018”, 0.020”

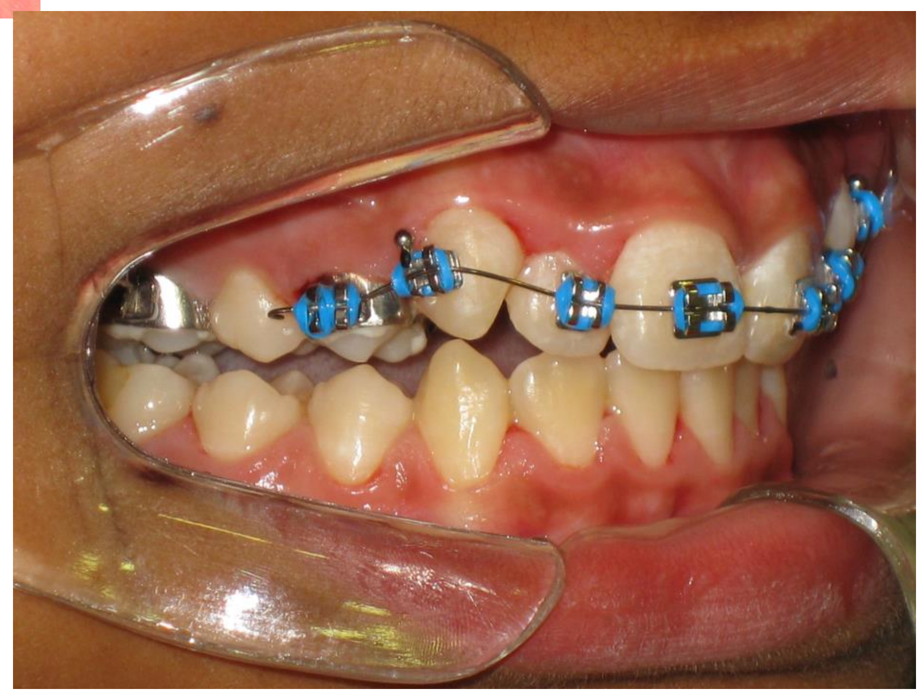
3) FINALIZAÇÃO

a) TMA
b) Aço retangulares



TIPOS DE FIOS

Alinhamento
inicial



Forças da mastigação

MASTIGAÇÃO – Dentes contactam por 1 segundo ou menos.

SUBSTÂNCIAS MACIAS – 1 a 2kg

OBJETO MAIS RESISTENTE – 50 Kg

Fios de Níquel –Titânio

1963 – desenvolvidas no Laboratório Naval Americano, em Silver Springs – Maryland

1972 – Unitek produziu fios chamados Nitinol, com 55% de níquel e 45% titânio

1985- “Chinese NiTi – superelástico

1986- Japanese NiTi – superelástico produzido pela GAC

Fios de Níquel –Titânio

Final década de 90 – desenvolvidos fios termoativos para Ortodontia

* recuperação elástica   * resiliência

ativados pela temperatura bucal

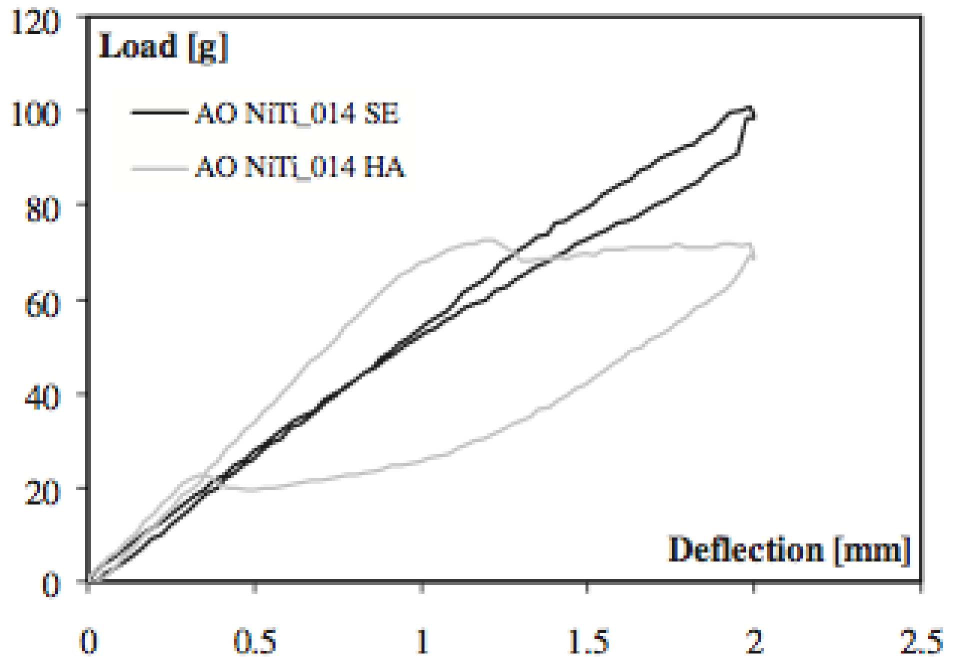
Fios de Níquel –Titânio adicionado com cobre

1) Mais resistentes à deformação permanente e melhor recuperação elástica

2) Menor módulo de elasticidade, alto poder de encaixe aos “brackets” com menor desconforto para o paciente

Fios de Níquel –Titânio adicionado com cobre

3)Platôs de carga contantes durante a desativação, o que garantiria a produção de forças mais constantes por maiores intervalos de tempo



GATTO et al, 2011

Temperatura intra-bucal

* 79% do tempo , a faixa de temperatura intra-bucal varia entre 33 e 37º

* A faixa de temperatura na região dos incisivos centrais e primeiros pré-molares se situa entre 35 e 36º, estando acima de 37º em apenas 1% do tempo.

MOORE e cols (1999)

Fios Estéticos

a) cobertos com teflon
b) cobertos com resina epoxídica
c) fios composto por uma matriz à base de nylon contendo fibras de silicone para reforço
d) fios feitos de material compósito polimérico reforçado com fibra de vidro

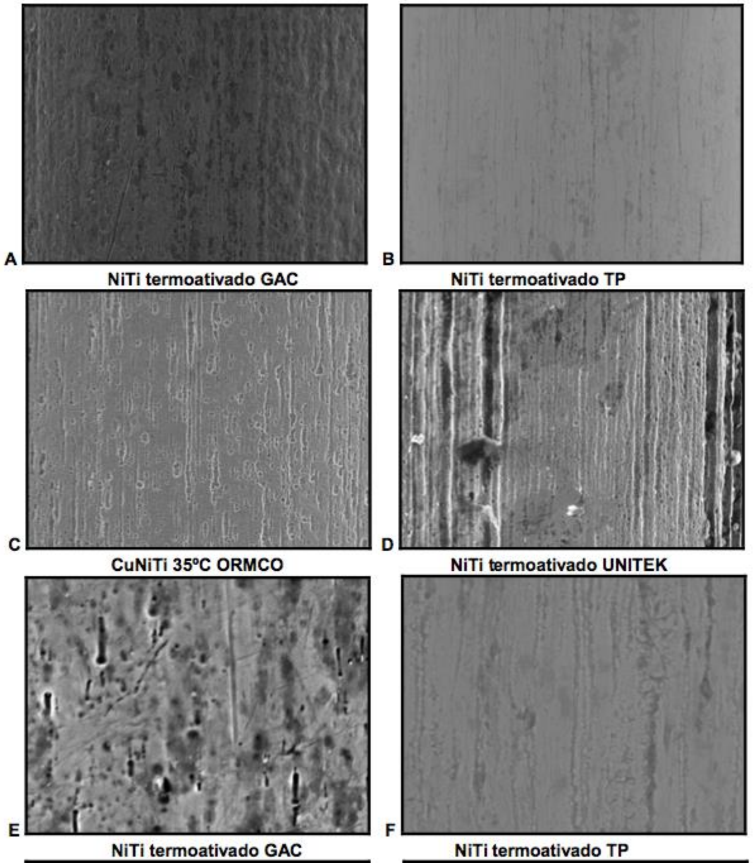
TESTES

- DSC
- Comportamento mecânico:
  - ensaios de tração
  - ensaios de flexão em 3 pontos
    * 3 brackets
    * arcadas dentárias

Figure 1. Deflection, with 1 mm blade, of mounted archwire kept in a water bath at a constant temperature of 37.0°C.

TESTES

- Teste de fricção
- MEV



Informações fornecidas pelas empresas

- “Escondidas” no site

3M Unitek

Orthodontic Wire Properties – Lateral Development Nitinol, Nitinol HA, Beta Titanium and Stainless Steel Archwires

ISO 15841

FORCE MAGNITUDES

Forces measured during unloading from three-point bending test with 10 mm span at 36 +/- 1 deg. C.
Occlusal - gingival direction.

Lateral Development Nitinol Archwires
Austenite finish temperature: 5 to 40 deg. C
Permanent deflection after unloading: 10% maximum

Size Descriptor	3 mm deflection		2 mm deflection		1 mm deflection		0.5 mm deflection	
	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
	(gm)	(gm)	(gm)	(gm)	(gm)	(gm)	(gm)	(gm)
12	40	90	30	80	30	80	40	90
13	40	100	40	90	40	90	40	100
14	60	140	50	130	50	130	50	130
16	90	210	80	190	70	180	70	180
18	130	330	110	260	100	250	100	250
20	170	430	140	350	130	330	120	300
14x25	150	360	120	300	120	290	130	310
16x22	170	430	150	360	140	350	150	360
16x25	220	550	190	460	170	430	180	440
17x25	230	560	190	460	180	450	180	450
18x25	270	660	210	530	200	490	180	450
19x25	320	790	240	600	220	550	200	500

Lateral Development Nitinol HA Archwires
Austenite finish temperature: 20 to 40 deg. C
Permanent deflection after unloading: 5% maximum

Size Descriptor	3 mm deflection		2 mm deflection		1 mm deflection		0.5 mm deflection	
	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
	(gm)	(gm)	(gm)	(gm)	(gm)	(gm)	(gm)	(gm)
14x25	120	290	70	180	60	140	50	130
16x25	170	430	100	250	90	210	80	200
17x25	170	410	90	210	70	160	60	150
18x25	190	480	100	250	80	200	70	160
19x25	240	590	110	260	80	190	60	150

Forces measured during unloading from three-point bending test with 10 mm span at 36 +/- 1 deg. C.
Occlusal - gingival direction.

Lateral Development Nitinol Archwires
Austenite finish temperature: 5 to 40 deg. C
Permanent deflection after unloading: 10% maximum

Size Descriptor	3 mm deflection		2 mm deflection		1 mm deflection		0.5 mm deflection	
	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
	(N)	(N)	(N)	(N)	(N)	(N)	(N)	(N)
12	0.39	0.88	0.29	0.78	0.29	0.78	0.39	0.88
13	0.39	0.98	0.39	0.88	0.39	0.88	0.39	0.98
14	0.59	1.37	0.49	1.27	0.49	1.27	0.49	1.27
16	0.88	2.06	0.78	1.86	0.69	1.77	0.69	1.77
18	1.27	3.24	1.08	2.55	0.98	2.45	0.98	2.45
20	1.67	4.22	1.37	3.43	1.27	3.24	1.18	2.94
14x25	1.47	3.53	1.18	2.94	1.18	2.84	1.27	3.04
16x22	1.67	4.22	1.47	3.53	1.37	3.43	1.47	3.53
16x25	2.16	5.39	1.86	4.51	1.67	4.22	1.77	4.31
17x25	2.26	5.49	1.86	4.51	1.77	4.41	1.77	4.41
18x25	2.65	6.47	2.06	5.20	1.96	4.81	1.77	4.41
19x25	3.14	7.75	2.35	5.88	2.16	5.39	1.96	4.90

Lateral Development Nitinol HA Archwires
Austenite finish temperature: 20 to 40 deg. C
Permanent deflection after unloading: 5% maximum

Size Descriptor	3 mm deflection		2 mm deflection		1 mm deflection		0.5 mm deflection	
	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
	(N)	(N)	(N)	(N)	(N)	(N)	(N)	(N)
14x25	1.18	2.84	0.69	1.77	0.59	1.37	0.49	1.27
16x25	1.67	4.22	0.98	2.45	0.88	2.06	0.78	1.96
17x25	1.67	4.02	0.88	2.06	0.69	1.57	0.59	1.47
18x25	1.86	4.71	0.98	2.45	0.78	1.96	0.69	1.57
19x25	2.35	5.79	1.08	2.55	0.78	1.86	0.59	1.47

Editorial Kokich /AJODO

Estudos in vivo

x

Estudos in vitro

EDITORIAL AJO-DO

In-vitro vs in-vivo materials research

Vincent G. Kokich, Editor-in-Chief
Tacoma, Wash

The theme of the 2013 Supplement and Product Guide is orthodontic materials. As clinicians, we rely on products produced by dental and orthodontic materials manufacturers from around the world. The safety and efficiency of these products is established by testing. Experimental testing can be performed clinically in patients (in vivo) or in the laboratory (in vitro). Obviously, tests that determine the safety of materials to be placed in the oral cavity should probably be performed in the laboratory so that any potentially harmful effects can be detected before clinical usage. However, when it comes to testing the efficiency of orthodontic materials, the results of both in-vivo and in-vitro testing are commonly seen in articles published in the *AJO-DO* and other orthodontic journals. Are there differences in the reliability of the results that are documented in vivo vs in vitro?

It might seem logical that the results of in-vitro testing would be more reliable, since all aspects of the experiment could be controlled in a laboratory setting. After all, in-vivo experiments performed in human subjects have many variables that could complicate the interpretation of the data. But there are 2 problems to consider. One is that the variability encountered during human experimentation must eventually be ascertained, because these variables can affect the efficiency of the product being tested. Second, it might not be possible to simulate all intraoral variables adequately in laboratory experiments.

For example, past studies have shown that nickel-titanium archwires are nearly unbreakable when tested in the laboratory by using a wide variety of methods to cause breakage. However, when nickel-titanium arch- about the performance of their products, the information in those reports could be meaningless when applied to the clinical performance of the same products.

Other orthodontic products perform differently in the laboratory compared with the oral cavity. For example, we rely on the bond strength of the composite material that we use to attach brackets to teeth. Most published studies that tested the shear bond strength of various types of bonding composites were performed in laboratory experiments. However, it has been shown that mouth rinses containing alcohol that are used by orthodontic patients can decrease the bond strength of the composite because they accelerate the aging and degradation of the polymeric adhesive.

Another example of materials testing that shows differences in the laboratory compared with the oral cavity is the efficiency of elastomeric chains when used to close spaces during orthodontic treatment. These types of materials are routinely tested in the laboratory and are even exposed to artificial saliva at temperatures that mimic those in the oral cavity. But there is something missing in these laboratory experiments that cannot be duplicated in the laboratory. Humans form a biofilm on teeth, brackets, archwires, and elastomeric chains. The biofilm of one patient is different from that of another patient. Researchers have shown that in-vivo exposure of elastomeric ligatures results in the buildup of biofilm, which becomes calcified and contributes to the degradation, and therefore the performance capabilities, of elastomeric chains.

I could go on with more examples, but here is my point: in-vivo testing of certain orthodontic materials produces much more clinically reliable information

TIPOS DE FIOS

ORIGINAL ARTICLE AJO-DO

Cross-section dimensions and mechanical properties of esthetic orthodontic coated archwires

Dayanne Lopes da Silva,[a] Claudia Trindade Mattos,[b] Eduardo Franzotti Sant' Anna,[c] Antônio Carlos de Oliveira Ruellas,[c] and Carlos Nelson Elias[d]
Rio de Janeiro, Brazil

Introduction: There has been continuing interest in the development and use of esthetic and effective orthodontic archwires. The aims of this study were to evaluate the inner alloy core dimensions of 4 brands of as-received esthetic coated wires and their mechanical properties before and after 21 days of oral exposure, compared with conventional stainless steel and nickel titanium wires. **Methods:** Four groups (Ortho Organizers, Carlsbad, Calif; TP Orthodontics, LaPorte, Ind; Orthometric, Beijing, China; and Trianeiro, Rio Claro, São Paulo, Brazil) of orthodontic archwires were tested. Five properties were evaluated: inner wire dimensions, modulus of elasticity, modulus of resilience, maximum deflection force, and load deflection curve characteristics. Images of the transverse sections from the specimens were made with a stereoscope. The inner alloy core dimensions of each wire were measured by using Image Pro Plus software (version 4.5; Media Cybernetics, Silver Spring, Md). All specimens were tested in a universal testing machine in a 3-point bending test. **Results:** Coated wires of the Ortho Organizers and Trianeiro groups showed greater reductions in their inner alloy core dimensions and produced lower loading and unloading forces and lower modulus of elasticity, modulus of resilience, and maximum deflection force values than did their control wires. Inner alloy core dimensions and the mechanical behavior of coated wires practically did not differ from the control wires in the TP Orthodontics and Orthometric groups. **Conclusions:** The reduction on the inner alloy core dimensions to compensate for the coating thickness seems to be the variable responsible for greater changes in the mechanical properties of esthetic coated wires. (Am J Orthod Dentofacial Orthop 2013;143:S85-91)

Table II. Means, standard deviations, and *P* values of independent-samples *t* test between control and coated wires in each group for wire dimensions (in)

	Stated dimensions		Measured inner alloy core dimensions		Control × coated	
			Height	Width	Height	Width
Group	Height	Width	Mean ± SD	Mean ± SD	P value	P value
I						
Control	0.018	0.025	0.01811 ± 0.00006	0.02513 ± 0.00004	<0.001	<0.001
Coated	0.018	0.024	0.01614 ± 0.00009	0.02211 ± 0.00009		
II						
Control	0.018	0.025	0.01802 ± 0.00003	0.02503 ± 0.00001	0.517	0.503
Coated	0.018	0.025	0.01803 ± 0.00003	0.02503 ± 0.00001		
III						
Control	0.018	0.025	0.01807 ± 0.00009	0.02513 ± 0.00012	0.599	<0.001
Coated	0.018	0.025	0.01810 ± 0.00009	0.02351 ± 0.00011		
IV						
Control	0.016	0.022	0.01616 ± 0.00004	0.02204 ± 0.00005	<0.001	<0.001
Coated	0.018	0.024	0.01586 ± 0.00008	0.02172 ± 0.00014		

ORIGINAL ARTICLE
AJO-DO

Factors related to the rate of orthodontically induced tooth movement

Alexander Dudic,[a] Catherine Giannopoulou,[b] and Stavros Kiliaridis[c]
Geneva, Switzerland

Introduction: The purpose of this study was to investigate the variations of orthodontically indu
movement in the maxillary and mandibular arches between patients and the factors such as age
presence of an interference that might influence the amount of tooth displacement. **Methods:**
a standardized experimental orthodontic tooth movement in 30 subjects, 57 premolars were move
during 8 weeks with the application of a 1-N force. Forty-four contralateral premolars not su
orthodontic tooth movement served as the controls. Plaster models from before and after the ex
tooth movement were digitized and superimposed to evaluate the amounts of tooth movement. Diff
tooth movement between the experimental and control groups were tested by an unpaired *t* te
experimental teeth, subject-related factors (age and sex) and tooth-related factors (location in the r
mandibular dental arch, and the presence or absence of an intra-arch or interarch obstacle
neighboring touching teeth or teeth interfering with the occlusion) were examined with analysis o
Multiple linear regression analysis was performed to determine correlations between tooth displace
sex, tooth location, and presence of an interference. **Results:** Each subject contributed at least 2 ex
premolars and 1 control premolar. The displacement of the orthodontically moved teeth was 2.42 r
0.3-5.8 mm). Younger subjects (<16 years; n = 19; number of teeth, 36) had significantly greater a
tooth displacement compared with older subjects (≥16 years; n = 11; number of teeth, 21): 2.6 ±
1.8 ± 0.8 mm; P <0.01. When an interarch or intra-arch obstacle was present, the amoun
movement was significantly less (2.6 ± 1.3 mm vs 1.8 ± 0.8 mm) (P <0.05). Neither sex nor the
the experimental teeth in the mandible or the maxilla had any effect. **Conclusions:** Younger patien
greater tooth movement velocity than did older ones. An interarch or intra-arch obstacle decr
amount of tooth displacement. (Am J Orthod Dentofacial Orthop 2013;143:616-21)

Orthodontic tooth movement has been defined as "the result of a biologic response to interference in the physiologic equilibrium of the dentofacial complex by an externally applied force."[1] Only small amounts of force might be required to effect this outcome, which is accompanied by remodeling changes in the periodontal ligament and alveolar bone.[2-5] The sequence of cellular, molecular, and tissue-reaction events during orthodontic tooth movement has been extensively studied.[6] Several factors, alone or in combination, might influence remodeling activities and ultimately tooth displacement. Among these, the concept of "an optimal orthodontic force" has been the subject of investigation for several years. However, animal research has shown that even with standardized, constant, and equal forces, the rate of orthodontic tooth movement can vary substantially among and even within subjects.[7,8] It was concluded that a wide range of forces can be applied to induce orthodontic tooth movement, and the rate is based mainly on patient characteristics. Several factors, such as age, drug consumption, diet, several systemic conditions, and other intrinsic genetic factors, have been shown to influence the rate of tooth movement.[9,10]

Clinically, differences in the rate of tooth movement even in the same patient can be observed. In certain cases, the role of neighboring touching teeth or occlusal interferences by antagonist teeth seem to influence the amount of the tooth displacement. However, no study has investigated the role of such interferences on the rate of tooth displacement.

tooth displacement. Among these, the concept of "an optimal orthodontic force" has been the subject of investigation for several years. However, animal research has shown that even with standardized, constant, and equal forces, the rate of orthodontic tooth movement can vary substantially among and even within subjects.[7,8] It was concluded that a wide range of forces can be applied to induce orthodontic tooth movement, and the rate is based mainly on patient characteristics. Several factors, such as age, drug consumption, diet, several systemic conditions, and other intrinsic genetic factors, have been shown to influence the rate of tooth movement.[9,10]

From the University of Geneva, Geneva, Switzerland.
[a]Assistant professor, Department of Orthodontics.
[b]Assistant professor, Department of Periodontology.
[c]Professor, Department of Orthodontics.
The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.
Supported by the Swiss National Science Foundation (grant 3200-127539).
Reprint requests to: Catherine Giannopoulou, Department of Periodontology, Dental School, University of Geneva, Rue Barthélemy-Menn 19, 1205 Geneva, Switzerland; e-mail, ekaterini.giannopoulou@unige.ch.
Submitted, July 2012; revised and accepted, December 2012.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2012.12.009

American Journal of Orthodontics and Dentofacial Orthopedics
May 2013 Vol 143 Issue 5

Desafios da Ortodontia

* Tratamento eficiente – bons resultados

* Tratamento rápido

* Tratamento com menor risco biológico


Obrigada pela vossa atenção!