

V. Quinzi*, R. Ferro**, F.A. Rizzo*,
E.M. Marranzini***, F. Federici Canova****,
S. Mummolo*, A. Mattei*, G. Marzo*

*Department of Life, Health & Environmental Sciences,
Postgraduate School of Orthodontics, University of L'Aquila,
L'Aquila, Italy

**Dentistry Unit, Cittadella Hospital, Health District n. 15 Veneto
Region, Cittadella (PD), Italy

***Private practice Taranto, Italy

****Private practice Parma, Italy

e-mail: vincenzo.quinzi@univaq.it

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The Two by Four appliance: a nationwide cross-sectional survey

ABSTRACT

Aim The aim of the study was to investigate how widespread is the use of the 2 x 4 appliance among Italian general dentists and specialists in orthodontics, as well as the type of treatment employed and length of use.

Methods We conducted a nationwide cross-sectional survey from July 14, 2016 to January 12, 2017 using an online questionnaire of 8 multiple choice questions, created by the SurveyMonkey® Company, on a population of Italian dentists and specialists in orthodontics affiliated with the Italian Society of Paediatric Dentistry (SIOI). This was made to assess how many clinicians knew and used this device in their clinical practice. We included 200 Italian dentists, 99 specialists in orthodontics and 101 general dentists of a mean age of 45 ± 15 years.

Results Results show that 93.94% of orthodontists have knowledge of and use this device in their clinical practice, while only 51.49% of the general dentists have knowledge of and use it ($p < 0.001$). The 51.92% of dentists and the 52.13% of orthodontists used the 2x4 appliance to treat both space management and incorrect overjet. Most of general dentists and orthodontists combined the 2x4 appliance with pre-adjusted brackets and accessory components such as

coil springs and power chains. While most of dentists (45.90%) used the 2x4 in association with appliances for space management, most of specialists (46.15%) applied the 2x4 in combination with both appliances for space management and high-pull headgear. Statistically significant differences were found also for the answers to the question "what is the average time of treatment?" among general dentists: the 32.79% used the 2 x 4 for less than 6 months of treatment, and the 67.21% used the 2 x 4 for more than 6 months of treatment. On the other hand 49.46% of orthodontists used the 2 x 4 for less than 6 months of treatment, and 50.54% of them for more than 6 months of treatment ($p = 0.041$).

Conclusions We conclude that the 2 x 4 appliance is widespread among orthodontists and about half of the general dentists, 93.94% and 51.49% ($p < 0.001$) respectively. We found that 67.21% of general dentists used the 2 x 4 for a more than 6 months of treatment. As far as the orthodontists, 49.46% used the device for less than 6 months of treatment and 50.54% of them for more than 6 months of treatment. These differences were statistically significant ($p = 0.041$).

Keywords 2x4 appliance, Two by four appliance, Interceptive orthodontics, Mixed dentition.

Introduction

The fixed appliance 2 x 4 comprises four brackets bonded onto the erupted maxillary permanent incisors, two bands cemented or two tubes bonded on the first permanent molars and a continuous archwire to provide/maintain good arch form. Depending on the technique and the operator's preferences, some accessory components such as rubber tubings and nickel titanium coil springs between the bands/tubes and brackets can be used, with the double purpose of increasing patient comfort and preventing arch ruptures (Fig. 1, 2).

This appliance allows rapid correction of many incipient malocclusions in a single short phase of fixed appliance therapy in the early mixed dentition stage [Mckeown and Sandler, 2001]. The versatility of this appliance permits to resolve various problems affecting the upper incisors in a simple manner and in a relatively short period (about 6 months). It can be used for rapid correction of crossbites in the anterior sector, to reduce overjet and to align ectopic incisors.

A 2 x 4 sectional fixed appliance offers more effective and efficient tooth positioning as it allows three-dimensional control of the involved teeth during correction of anterior crossbites or aligning ectopic incisors. Rotations, diastemas and incorrect tooth inclinations and angulations may therefore be treated very quickly using this versatile

appliance [Mckeown and Sandler, 2001].

This appliance not only quickly restore anterior aesthetics but it may also reduce the complexity and duration of any subsequent treatment [Mckeown and Sandler, 2001].

A quadhelix can be soldered to molar bands or palatal sheaths to provide a simultaneous correction of a posterior crossbite if required [Dowsing and Sandler, 2004]. The 2 x 4 can be combined with a rapid palatal expander (RPE) too. Proper oral hygiene is crucial [Mummolo et al., 2013; Marchetti et al., 2009; Ortu et al., 2014] in order to decrease the risk of demineralisation associated with a fixed appliance [Dowsing and Sandler, 2004].

Background

The concept of sectional appliances is not new. Johnson introduced the twin-wire arch in the 1930s, which included incisor and molar bands and small-diameter twin wires sheathed in buccal tubing along with various auxiliaries such as palatal arches, intermaxillary hooks and coil springs. This resulted in an appliance with a flexible anterior section to allow alignment of imbricated incisors and rigid buccal sections to prevent distortion [Johnson, 1934]. It is worthwhile to underline that the 2 x 4, although geometrically similar to Rickett's utility arch, is not the same appliance. The 2 x 4 is a device that does not require the use of bends on the arch contrary to the utility arch [Ricketts et al., 1972].

In a study McKeown e Sandler [2001] presented four cases using the 2x4 appliance, in which they outlined the effectiveness and versatility of this device. By the use of this appliance, the authors resolved the malposition of an unerupted and palpable labially central incisor, due to a compound odontome; they corrected an anterior crossbite and tractioned and aligned the central incisor after the removal of two supernumerary teeth lying palatal to the permanent central incisor preventing its eruption; finally they obtained the correction of a unilateral posterior crossbite, alignment of the maxillary incisors and space closure using a 2 x 4 combined with a removable quadhelix.

In a second study conducted by Dowsing and Sandler [2004], the authors highlight the versatility of the 2 x 4 appliance and how it can be adapted for rapid correction of retroclined central incisors, impacted/ectopic incisors, rotated and irregular incisors and the correction of a posterior crossbite with central incisors in crossbite in



FIG. 1 The components of the 2 x 4 appliance.

combination with a soldered quadhelix.

Since in literature there are few scientific publications concerning the 2 x 4 appliance, we decided to conduct a nationwide cross-sectional survey on this device.

Aim of the study

The aim of the study was to investigate how widespread is the use of the 2 x 4 appliance among Italian general dentists and specialists orthodontists, why and how they used it and the length of treatment.

Materials and methods

We conducted a nationwide cross-sectional survey from July 14, 2016 to January 12, 2017 using an online questionnaire on a population of Italian dentists and specialists in orthodontics members of the Italian Society of Pediatric Dentistry (SIOI), to assess how many clinicians knew and used the 2 x 4 appliance in their clinical practice. We included 200 Italian clinicians (99 specialists in orthodontics and 101 general dentists) with a mean age of 45 ± 15 years.

The questionnaire, created by the SurveyMonkey® Company, consisted of an initial registration form and of 8 multiple choice questions. We asked the clinicians if they knew the 2 x 4 appliance, for what type of treatment they



FIG. 2 The 2 x 4 appliance intraorally.

used it, types of brackets and arches used, if they used accessory components or appliances in association with this device, and what was the average treatment length.

Answers were then collected through the SurveyMonkey website. Descriptive statistics, such as mean and standard deviation, and frequencies with percentages, were used to examine the characteristics of the sample. The differences between groups were assessed with the χ^2 test for categorical variables and p -value <0.05 was considered statistically significant. The data were analysed using the software Stata 15/IC.

Participants gave their consent to the processing of their data for the purpose of this study.

Results

Of a total of 200 responders, 101 were dentists and 99 were specialists in orthodontics, with mean age 45 ± 15

years. Of the participants, 57.22% were female.

Of the total sample of 200 responders, 72.50% knew and used the 2 x 4 appliance, while 27.50% had no knowledge of it; 28.08% used the 2 x 4 for space management, light-medium crowding or spacing; 12.33% used the appliance for the management of increased overjet associated with a skeletal Class I or Class II or for decreased overjet to correct anterior crossbites; 52.05% used the 2 x 4 for both space management and correction of increased or decreased overjet.

At the question about "which type of brackets do you use", 74.05% of responders used preadjusted brackets, while 25.95% used non-preadjusted brackets.

Of the total sample, 42.58% applied super elastic archwires, 14.19% used stainless steel archwires and 43.23% applied both super elastic archwires and stainless steel archwires.

At the question "Do you use accessory components?", 12.99% used open or closed coil springs, 22.08% power

Questionnaire questions and answers	n (%)
Q1: Type of clinical activity	
General dentistry	101 (50.50)
Specialist in orthodontics	99 (49.50)
Q2: Do you know the 2 x 4 appliance?	
Yes	145 (72.50)
No	55 (27.50)
Q3: What do you use it for?	
Space management (light - medium crowding/diastema)	41 (28.08)
Overjet Class II (Ovj +) / Class III (Ovj -)	18 (12.33)
Space management (crowding/diastema) + overjet Class II (Ovj +)/ Class III (Ovj -)	76 (52.05)
Other	11 (7.53)
Q4: Which type of brackets do you use?	
Non-preadjusted brackets	41 (25.95)
Preadjusted brackets	117 (74.05)
Q5: What type of archwire do you use?	
Super elastic archwire	66 (42.58)
Stainless Steel archwire	22 (14.19)
Super elastic archwire and stainless steel archwire	67 (43.23)
Q6: Do you use accessory components?	
Open or closed coil springs	20 (12.99)
Power chains	34 (22.08)
Open or closed coil springs + power chains	75 (48.70)
Other (other components/nothing)	25 (16.23)
Q7: Do you use the 2 x 4 appliance in association with other devices?	
Appliances for space management (ERP/Quadelix/Lingual Arch...)	65 (42.76)
High-pull headgear	7 (4.61)
High-pull headgear + Appliances for space management (RPE/Quadhelix/Lingual Arch...)	65 (42.76)
Other (with other appliances/2x4 only)	15 (9.87)
Q8: What is the average length of treatment?	
Less than 6 months of treatment	66 (42.86)
More than 6 months of treatment	88 (57.14)

TABLE 1 Responses to the online questionnaire, n=200.

Questionnaire questions and answers	n (%)		p-value*
	General Dentistry	Specialist in Orthodontics	
Q2: Do you know the 2x4 appliance?			
Yes	52 (51.49)	93 (93.94)	<0.001
No	49 (48.51)	6 (6.06)	
Q3: What do you use it for?			
Space management (light - medium crowding/diastema)	15 (28.85)	26 (27.66)	0.933
Overjet Class II (Ovj +) /Class III (Ovj -)	7 (13.46)	11 (11.70)	
Space management (crowding/diastema) + overjet Class II (Ovj +)/Class III (Ovj -)	27 (51.92)	49 (52.13)	
	3 (5.77)	8 (8.51)	
Q4: Which type of brackets do you use?			
Non-preadjusted brackets	17 (26.98)	24 (25.26)	0.809
Preadjusted brackets	46 (73.02)	71 (74.74)	
Q5: What type of archwire do you use?			
Super elastic archwire	27 (43.55)	39 (41.94)	0.780
Stainless Steel archwire	10 (16.13)	12 (12.90)	
Super elastic archwire and stainless Steel archwire	25 (40.32)	42 (45.16)	
Q6: Do you use accessory components?			
Open or closed coil springs	7 (11.29)	13 (14.13)	0.822
Power chains	13 (20.97)	21 (22.83)	
Open or closed coil springs + power chains	33 (53.23)	42 (45.65)	
Other (other components/nothing)	9 (14.52)	16 (17.39)	
Q7: Do you use the 2 x 4 appliance in association with other devices?			
Appliances for space management (ERP/Quadelix/Lingual arch...)	28 (45.90)	37 (40.66)	0.640
High-pull headgear	4 (6.56)	3 (3.30)	
High-pull headgear + appliances for space management (RPE/Quadelix/Lingual arch...)	23 (37.70)	42 (46.15)	
Other (with other appliances/2x4 only)	6 (9.84)	9 (9.89)	
Q8: What is the average length of treatment?			
Less than 6 months of treatment	20 (32.79)	46 (49.46)	0.041
More than 6 months of treatment	41 (67.21)	47 (50.54)	
*Using χ^2 test			

TABLE 2 Questionnaire responses by general dentists and specialists in orthodontics.

chains and 48.70% both open or closed coil springs and power chains.

With respect to the use of the 2 x 4 appliance in association with other devices, 42.76% of clinicians used it in association with appliances for space management, i.e. rapid palatal expander (RPE), quadhelix and lingual arch, 4.6% in combination with high-pull headgear, 42.76% applied the 2 x 4 in combination with both high-pull headgear and devices for space management (RPE, quadhelix, lingual arch); finally the remaining 9.8% of respondent used it with other appliances or simply alone.

At the last question about "What is the average length of treatment?", 57.14% of clinicians answered more than 6 months, whereas 42.86% stated less than 6 months (Table 1).

Table 2 shows the answers to the questionnaire given by general dentists and orthodontists. For the question "Do you know the 2 x 4 appliance?" 93.4% of the orthodontists knew this device vs. only 51.4% of general dental practitioners. This difference is statistically

significant ($p < 0.001$). Among the general dentists, 28.85% of them used the 2 x 4 for space management, 13.46% for correction of increased/decreased overjet, 51.92% used it for both space management and overjet corrections.

Of the orthodontists, 27,66% used the 2 x 4 for space management, and 11.70% for overjet correction, while 52.13% of orthodontists used it for both space management and overjet corrections. Most responders, respectively 73.02% of general dentists and 74.74% of orthodontists, used preadjusted brackets in their clinical practice. On the contrary, 26,98% of general dentists and 25.26% of orthodontis applied non-preadjusted brackets.

At the question "Which type of archwire do you use", 43.55% of general dentists answered super elastic archwires, 16.13% stainless steel archwires, and 40.32% answered both nichel titanium and stainless steel archwires; 41.94% of orthodontists answered super elastic archwires, 12.90% stainless steel archwires, and finally 45.16% of them applied both type of archwires.

Most general dentists and orthodontists, respectively 53.23% and 45.65%, applied open or close coil springs and power chains as accessory components of the 2 x 4.

With regard to the use of the 2x4 in association with other devices, dentists combined it with appliances for space management in 45.90% of the cases, only 6.56% of them used it with high-pull headgear, 37.70% used it with both appliances for space management and high pull headgear; 40.66% of orthodontists used the 2x4 in combination with devices for space management: 3.30% with high pull headgear and 46.15% with both appliances for space management and high pull headgear.

Statistically significant differences were found also for the question "What is the average length of treatment?", as 32.79% of general dentists used the 2 x 4 for less than 6 months, and 67.21% for more than 6 months of treatment. In the orthodontists sample, 49.46% used the 2 x 4 for less than 6 months and 50.54% more than 6 months of treatment ($p=0.041$) (Table 2).

Discussion

We found that the 2 x 4 appliance is known and used in the clinical practice by the totality orthodontists and about half of general dentists members the Society of Pediatric Dentistry ($p<0.001$). From our results, clinicians choose the 2x4 over other devices for management of defective space (such as rotation, malpositioning or crowding), or excess space (diastemas) in the case of skeletal Class I, II and III patients. In fact, 28.85% of general dentists and 27.66% of orthodontists used the 2 x 4 for the solution of space problems without sagittal positive or negative overjet, in skeletal Class I patients. Finally, 51.92% of general dentists and 52.13% of orthodontists choose the 2x4 as an interceptive orthodontic appliance for the management of space problems associated with increased or decreased overjet, therefore in patients with Class II or III malocclusion. A very small percentage of clinicians choose the 2 x 4 to solve problems related to the increased or decreased overjet: only 13.46% of general dentists and 11.70% of orthodontists, respectively.

Partial fixed treatment with the 2 x 4 is a treatment option that helps in the early correction of simple and minor malocclusions such as rotation or malpositioning involving one or more teeth. It can also help in correcting complex malocclusions, which must be carried out in two steps with an early correction of mild malocclusions by a fixed partial appliance and, later, with a comprehensive treatment [Fatima et al., 2015]. Early correction is important in order to prevent further complications in malocclusion and correct the relationship of malaligned or malpositioned teeth with their opposite and contralateral ones [Proffit, 2012].

In literature, one of the main indications of the 2 x 4 is the correction of the anterior crossbite, as shown in the studies of Gu et al. [2000], typically Class III malocclusions.

It is necessary to differentiate the pure (skeletal) Classe III from the pseudo- Class III (dentoalveolar/functional) malocclusions. From an aepidemiological standpoint, it is useful to point out that the Chinese population has a relatively high incidence of Class III malocclusion (1/20). More than half of these patients have a pseudo-Class III [Lin, 1985]. In a study conducted in Italy (Padova) by Ferro et al. [2016] there is a very low incidence of cross-bite (anterior or posterior) (3.7%). In this area of Northern Italy there is a very low incidence compared to the findings of studies conducted in the USA and Europe.

In the study of Gu [2000] 17 consecutive patients (mean age 9.7 years) with pseudo-Class III malocclusion were treated with a simple fixed appliance, whereas 20 patients [mean age, 8.5 years] with skeletal Class III and anterior crossbite were treated with reverse headgear. Lateral cephalometric radiographs taken at the beginning of treatment, end of the treatment, and 1 year after the active treatment, were analysed by modified Pancherz analysis. After active treatment the overjet correction was achieved using the 2 x 4 and reverse headgear. The overjet correction provided by the 2 x 4 appliance was due to dental changes only. In the reverse headgear group, 60% of the overjet correction was due to dental changes and 40% due to skeletal changes. During the 12-month follow-up period, the overjet in the 2x4 group was unchanged due to dental compensation.

In the study by Hägg et al. [2004] and Reyes [2014] 27 patients with pseudo-Class III were treated with the 2 x 4. After 5 years, 25 patients were examined, 20 of them did not need a second phase of treatment.

In another study by Amlani et al. [2007], the 2 x 4 appliance was used to correct anterior crowding. The study evaluated the presence of root resorption in the lateral incisor after active orthodontic treatment in the early mixed dentition. They recruited 26 patients from the Children's Clinic at the Schulich School of Medicine and Dentistry, University of Western Ontario, who underwent active orthodontic treatment consisting in the application of a 2 x 4 appliance with Ni-Ti wire to correct anterior crowding. For each patient, pre-treatment panoramic radiographs and post-treatment periapical radiographs were taken using the parallel technique. For each patient, the presence of root resorption in the lateral incisors was qualitatively assessed in post-treatment periapical radiographs. The methods described by Ericson et al. [1987b] were used for canine measurements on pre-treatment panoramic radiographs. The angle between the canine and the midline and the angle between the canine and the long axis of the lateral incisor were measured, as potential risk factors for root resorption in the lateral incisor [Ericson et al., 1987b 1988] (Fig. 1). Finally, the most medial position of the canine crown was assessed and the position was categorised into sectors 1 to 5 [Ericson et al., 1987b]. To increase the accuracy of the study all measurements were repeated a week later by the same operator. Non-significant differences were

found between the two measurements. Root resorption was seen in 4 out of 50 (8%) lateral incisors. The results showed that the patients who had root resorption had the canine with an unfavourable position and inclination [Ericson et al., 1987a, 1988, 2000a, 2000b, 2002]. The authors state that by carefully selecting the case, planning the treatment and monitoring the permanent canine position and inclination the risks of a root resorption of the maxillary lateral incisors can be significantly reduced. Finally they found that performing active orthodontic treatment in the early mixed dentition does not lead to root resorption when the case is properly chosen.

With respect to the technique employed with the 2 x 4 appliance, most dentists (73.02%) and orthodontists (74.74%) applied preadjusted brackets; 43.55% of general dentists used super elastic archwires, and 45.16% of orthodontists used either super elastic archwires or stainless steel archwires. Both general dentists and orthodontists used both coil springs and power chains, respectively 53.23% and 45.64%; 45.90% of dentists and 40.66% of orthodontists combined the 2 x 4 with space management devices, such as rapid palatal expander (RPE), quadhelix and lingual arch to correct crowding in association with posterior crossbite. Finally, while most of orthodontists (46.15%) applied the 2x4 in combination with devices for space management and high-pull headgear to solve various problems affecting the upper incisors and to reduce the overjet, only the 37.70% of dentists used this method. However, these data do not have a statistically significant value.

In the study of Mckeown [2001], 32.79% of general dentists and 49.46% of orthodontists used the 2 x 4 for less than 6 months of treatment, while 67.21% of general dentists and 50.54% of orthodontists used it 2 x 4 for more than 6 months ($p=0.041$). Since this sample does not represent the totality of clinicians on Italian population, it is advisable to carry out an appropriate investigation on a larger scale.

Conclusions

We conclude that knowledge and use of the 2 x 4 appliance is widespread among orthodontists (93.94%) and about half of general dental practitioners (51.49%) ($p<0.001$).

About half of both of dentists and orthodontists (51.92% and 52.3% respectively) used the 2 x 4 appliance for space management and overjet. Most general dentists and orthodontists combined the 2 x 4 appliance with preadjusted brackets and accessory components such as coil springs and power chains. While most general dentists (45.90%) use the 2 x 4 in association with appliances for space management, most orthodontists (46.15%) applied the 2x4 in combination with both appliances for space

management and high-pull headgear.

We found that 67.21% of general dentists used the 2 x 4 for more than 6 months of treatment, while 49.46% and 50.54% of orthodontists used the 2 x 4 for a less than 6 months and more than 6 months of treatment, respectively. These differences were statistically significant ($p=0.041$).

We believe that the 2 x 4 is a valid option in interceptive orthodontics and its diffusion is advisable not only among specialists in orthodontics, but also among general dentists. Further studies on this appliance are required in the future.

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