ORIGINAL ARTICLE

# Comparison between traditional and predictive methods in Prediction of post treatment mandibular arch

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**Abstract**

**Background and aim:** The aim of present study was to predict post treatment space available of mandibular arch and compare this method of measurement with the previous methods.

**Materials and methods:** Pretreatment lower dental arch models of 33 patients attending to the department of orthodontics of Tehran University of medical sciences were randomly selected. Two conventional methods of brass wire and sectional way were done for estimating space available in traditional method. In predictive method two mathematical arch forms, β-function and the sixth degree polynomial function were selected as the based arches. Post treatment arch perimeter predicted according to these arch forms separately and finally the results were compared with traditional method of brass wire.

**Results:** According to this study, two traditional methods are so closed to each other and also two predictive methods, but differences between traditional method and predictive methods measurements were considerable.

**Conclusions:** Using of post treatment arch parameters would be useful to predict post treatment space available in arches, and also detecting arch form, the position of the teeth, the retention requirements and so on.

**Keywords:** β-function, polynomial function, space analysis.

Received 10February 2014; accepted 4March 2014;Published 7 June 2014
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## Introduction

Space analysis is an essential stage in the diagnosis and treatment planning in orthodontics when deciding extraction.[1] The analysis of space problems in relation to etiology, methods of measurement and treatment plans have been extensively dealt with in the literature.[2-5] Often the space analysis viewed as the deficit between the sum of the mesiodistal widths of the teeth in an arch and the available arch perimeter to accommodate the teeth.[1,2,6] There are several methods for analyzing space.[1] In Merrifield total space analysis[7] cephalometric corrections and the curve of spee have been added to space required measurements. The space available has been measured with some methods by dividing the arch into sections or by curving a brass wire on the arch .[2,6,7] Recently by introduction of the mathematic arch form formulas it is possible to have a precise measurement of arch perimeter.[8] Until now, various geometric forms and mathematical function have been presented for dental human arch .[9-15] These geometric figures are so helpful during orthodontic treatment and constructing preformed arch wires.[8] The commonly arch form formulas are β-function and the sixth degree polynomial function . [9-11, 13] It seems that β-function formula is so close to dental arch shape that determine by two parameters of arch depth and arch width at the second molar area,[9,11] but the sixth degree polynomial function formula needs posterior and anterior arch parameters both including arch width and depth at canine and second molar region.[11] If we could predict the post treatment arch parameters (according to the treatment planning) then it is possible to calculate the arch perimeter precisely and thus we have a reliable and practical space analysis.[16] Since mandibular arch usually considered as major reference for diagnosis and treatment planning, this study was made on the basis of lower arch parameters.

The intend of present study was to predict post treatment arch perimeter of mandibular arch for the mathematical space analysis in lower jaw and finally comparing this method of space available measurement with the previous methods.

## Material &Methods

For comparing traditional measurements of space available with predicting post treatment arch perimeter method, lower study models of 33 patients(13 male and 20 female with the mean age of 13.6 years) attending to the department of orthodontics of Tehran University of medical sciences were randomly selected. All of the models were in permanent dentition stage with no missing, no previous extraction and no obvious arch asymmetry.

Two conventional methods of brass wire and sectional were accomplished for estimating space available in traditional method. In predictive method two mathematical arch forms, β-function and the sixth degree polynomial function were selected as the based arches for their accuracy and mathematic formulas. For predicting final arch perimeter four post treatment arch parameters were required consisting of intermolar width, molar arch depth, intercanine width and canine arch depth.

Since correction of anterior segment crowding and incisor inclination during treatment effects on arch depth and arch length, so we should know how these parameters influence on arch dimension to predict post treatment space available. In this way we used some formulas obtained from previous studies.

Regarding Braun study [9], there is a dynamic relationship between arch length (perimeter) changes ($\Delta L$) and lower anterior inclination changes ($\Delta\Theta$) in mandibular aligned anterior segment, as $\Delta\Theta=2.874(\Delta L)-1.678$ and the relationship between arch depth changes ($\Delta D$) and $\Delta L$ is $\Delta D=0.743(\Delta L) - 0.439$. With calculating $\Delta L$ from the first formula and substituting it in the second one, the new relationship obtains between $\Delta D$ and $\Delta\Theta$ as: $\Delta D=0.258(\Delta\Theta) - 0.005$

By using this formula it is possible to predict arch length and arch depth after aligning the anterior segment.

On the other hand, the amount of required canine retraction (CR) to relieve crowding and/or protrusion could be calculated by the formula introduced by Noroozi [10] (Figure 1 and Table 1):

**Figure 1:** C: distal contacts of lower canine before retraction, C′: distal contact of canine after retraction, P: Distal contacts of lower first premolars before canine retraction; In this figure, sin a = [(pp − cc)/2cp]

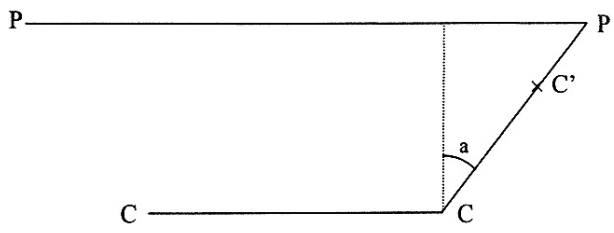



**Table 1**: Different Values of k

| AAP*, mm | k |
|---|---|
| AAP ≥ 36.5 | 0.622 |
| 30.7 < AAP < 36.5 | 0.655 |
| AAP ≤ 30.7 | 0.714 |

AAP indicates anterior arch perimeter. The AAP is the sum of the mesiodistal widths of 6 anterior mandibular teeth (from Noroozi H. Formula to determine the amount of retraction of mandibular canines. Angle orthod 2000;70:154-156)

CR= [incisor retraction (ΔD)/ (Cos*a* + 2KSin*a*)] + (crowding/2)

After canine retraction alone, the new arch depth is: the last arch depth + CR.Cos*a* and the new arch width is: the last arch width + 2CR.Sin*a*

So, arch length and depth after canine retraction can be also estimated through this formula.

In conclusion post treatment parameters were obtained considering anterior segment alignment and canine retraction.

First of all, parameters of CS and ΔΘ were defined. CS was considered as spacing minus crowding; positive CS indicates some spacing and negative CS indicates some crowding. ΔΘ was also considered as patient IMPA minus the recommended IMPA; positive ΔΘ indicates the need for some lingual tipping and negative ΔΘ indicates the need for some labial tipping.

Based on above data and by categorizing anterior lower arch treatment requirements, the following circumstance could be considered:

1) If ΔΘ>0 and CS>0 (Some spacing and also need for lower anterior inclination correction with lingual tipping) the amount of lower anterior inclination correction that is possible by using the spacing (ΔΘ`) is:

ΔΘ`=2.874(CS)-1.678

If ΔΘ`> ΔΘ means the amount of spacing is enough for IMPA correction and then required canine retraction is zero. As it mentioned above the arch depths changes following this inclination correction resulted from this equation: ΔD=0.258ΔΘ` -0.005

If ΔΘ`< ΔΘ then ΔΘ`` (ΔΘ``= ΔΘ- ΔΘ`) is the amount of required IMPA reduction beyond the existed spacing. Then we need some canine retraction (CR) that is:

CR= (0.258 ΔΘ``-0.005)/ (Cos*a* +2KSin*a*)

New canine arch width and depth and molar arch width could be calculated:

New CAD (canine arch depth) = Primary CAD - ΔD + CR.Cos*a*

New CAW (canine arch width) = Primary CAW + 2CR.Sin*a*

New MAD (molar arch depth) = Primary MAD – (0.258ΔΘ -0.005)

2) If ΔΘ>0 and CS<0 (Some crowding and also need for lower anterior inclination correction with lingual tipping) then the amount of canine retraction for elimination of crowding and protrusion is:

CR= (0.258 ΔΘ-0.005)/ (Cos*a* +2KSin*a*) + |CS/2|

After these retractions the new arch parameters are:

New CAD = Primary CAD + CR.Cos*a*

New CAW = Primary CAW + 2CR.Sin*a*

New MAD = Primary MAD – (0.258ΔΘ -0.005)

3) If ΔΘ<=0 and CS<0 (Some crowding and also need for lower anterior inclination correction with labial tipping) then we need some anterior labial tipping that

help us to eliminate partial or total crowding. According to Brown formula the amount of spaces that created by lower anterior labial tipping is:

$\Delta L = (|\Delta\Theta| + 1.678)/2.874$

If $|CS| <= \Delta L$ that means the created space is equivalent or more than space required, then the arch parameters changes after crowding elimination are:

New CAD = Primary CAD + ΔD ($\Delta D = 0.743|CS| - 0.439$)

New CAW = Primary CAW

New MAD = Primary MAD + ΔD ($\Delta D = 0.743|CS| - 0.439$)

If $|CS| > \Delta L$ that means the created space is less than space required, then we need some canine retraction (CR) equal to:

$CR = (|CS| - \Delta L)/2$

And therefore the new arch parameters are:

New CAD = Primary CAD + ($0.258|\Delta\Theta| - 0.005$) + CR.Cos*a*

New CAW = Primary CAW + +2CR.Sin*a*

New MAD = Primary MAD + ($0.258|\Delta\Theta| - 0.005$)

By estimating post treatment arch depth and arch length after incisor inclination correction and canine retraction, these new parameters substituted in mathematical formulas of arch form as bellow:

β-function formula:

$$Y = 3.0314D \left( 0.25 - \frac{X^2}{\ } \right)^{0.8}$$

(D: arch depth at second molar area, W: inter second molar width)

Six degree polynomial function formula:

$$Y = 64\left(\frac{D_c W_m^2 - D_m W_c^2}{W_c^6 W_m^2 - W_c^2 W_m^6}\right) X^6 + 4\left(\frac{D_c W_m^6 - D_m W_c^6}{W_c^2 W_m^6 - W_c^6 W_m^2}\right) X^2$$

$D_C$: arch depth at canine area, $D_m$: arch depth at second molar area, $W_C$: inter canine width, $W_m$: inter second molar width)

Finally the post treatment arch perimeter could be calculated with this integral [17]:

$$L = \int_{-W/2}^{W/2} \sqrt{1 + \left(\frac{dy}{dx}\right)^2}\, dx$$

(L: arch perimeter; W: intermolar width)

It should be taken into consideration that post treatment intermolar width does not change after correction of anterior segment crowding and inclination or canine retraction, so the original value were used. Since this integral calculates the arch perimeter from distobuccal cusp of the molar in one side to another side of the lower arch; the distances between distal contacts point (heights of contour) of molars to distobuccal cusps must be added to the arch perimeter.

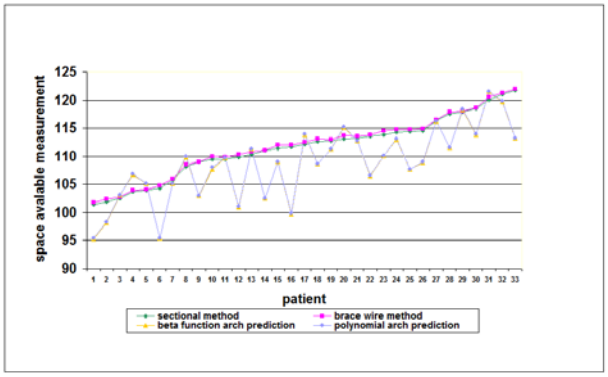
In this way post treatment arch perimeter estimated according to β-function and the sixth degree polynomial function arch forms separately and finally the results (post treatment space available) were compared with traditional method of brass wire.

## Results

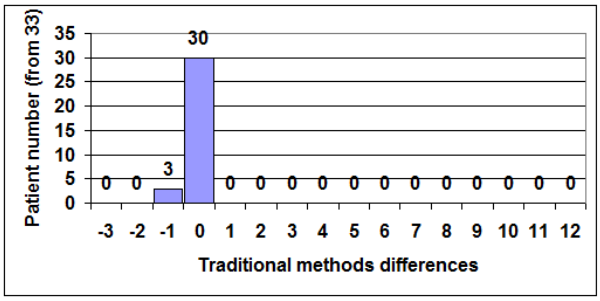
According to this study, significant differences were detected between traditional space available measurement method and predicting post treatment ones as it is shown in Table 2. Graph 1 shows the space available measurements with these methods in all study models.

As it could be expected two traditional methods are so closed to each other (graph 2); and also two prediction methods(graph3), but differences between traditional method and prediction methods measurements were considerable (p=0.00) as which only in 5 cases from 33 cases difference is limited to 0 mm (-0.5 to 0.5) (graph 4 and 5).

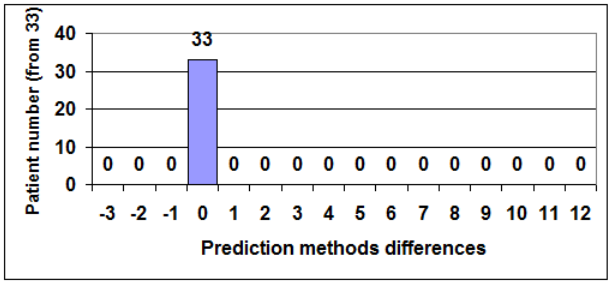
**Graph 1:** Comparison of space available measurement methods in all patients



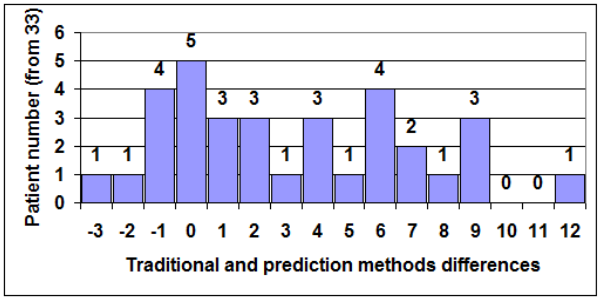

**Graph 2:** Difference between "brace wire measurements" and "sectional measurements"



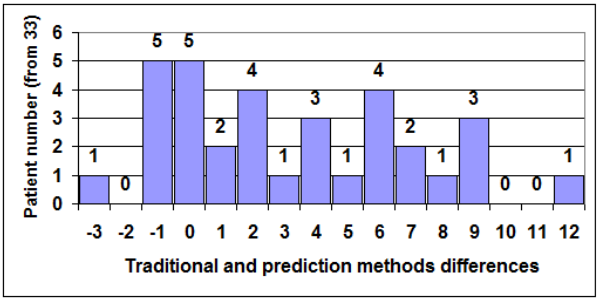

**Graph 3:** Difference between "β-function arch form prediction measurements" and "polynomial arch form prediction measurements"




**Graph 4:** Difference between "brace wire measurements" and "polynomial arch form prediction measurements"




**Graph 5:** Difference between "brace wire measurements" and "β-function arch form prediction measurements"




## Discussion

In this study the mathematical space available in lower arch, with more attention to arch form parameters and its changes following the correction of anterior crowding, spacing and inclination compared with traditional method.

Introduction of mathematic formulas for the human dental arch form and estimation of the parameters changes that influenced arch form make it possible to predict post treatment form of the arch, stability requirements, arch perimeter and so on. Besides, by calculation of the amount of canine retraction, it would be easier to determine the anchorage requirements of patients. For many years clinician tried to describe dental arch based on its figuration and arch parameters which resulted in introduction of several geometric arch forms. Among all, β-function was one of the most accurate representatives for human dental arch that was introduced by Braun.[9] In spite of all the advantages, inability of appropriate adaptation with tapered and square arches was a big deficit. After that researches were also continued to find more precise formula. In this way polynomial arch forms introduced using more parameters which is flexible in both anterior and posterior region of dental arch.[11,12] The curve of this equation can be wide or narrow in the anterior as well as posterior area and so representing the dental arch with high accuracy for the square and tapered forms as well as ovoid ones. Besides, the six-degree was reported to be the best one for definition of dental arch forms because of including the anterior curvature of mandibular arch that is compromised in lower degree ones.[15]

By definition of arch forms as a formula, it might be possible to detect each dimension of arch due to changes during treatment. So we tried to determine post

treatment space available by using these formulae. From several geometric arch forms, β-function and the sixth degree polynomial function formulas were selected because of their accuracy and including all of the arch forms.

According to this research, significant differences between traditional and predictive methods of space available measurements were observed which was expected; since in traditional methods crowding, spacing and anterior inclination correction were not considered when estimating space available. In traditional space analysis anterior inclination correction were calculated in space required based on Tweed's suggestion[18] (0.8 mm space for every 1º lower incisor retraction) or Rricketts[19] (2 mm change in arch perimeter for every 1 mm anteroposterior movement of lower incisors) regardless of existing crowding, spacing and arch parameters changes due to anterior inclination correction.

The dynamic relationships of mandibular dental arch in combination with mathematical arch forms provide us the possibility of accurate and actual space analysis. Since space analysis is one of the most important stages during diagnosis and treatment planning, predicting post treatment space available could be so useful and guide the clinician to make the best decision considering maximal stability and esthetic. The calculation of post treatment arch parameters not only help us to predict post treatment available space in arch, but also provide us the arch form, the position of the teeth, the retention requirements and so on. This method could be also useful in preparing patients for implants and/or surgery by predicting post treatment parameters of dental arch.

## Conclusion:

- The amount of space available was not significantly different in two traditional methods.

- Post treatment space available in predicting method, showed no differences between two mathematical dental arch forms.

- Significant differences were detected between traditional space available measurement method and predicting post treatment ones.

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