Original Paper

Theoretical Study on the Mechanics of the Conjunct Gnatoprothetic Devices in the Context of Occlusive Function Rehabilitation

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ABSTRACT: The partially intercalated edentation offers the practitioner the possibility of the functional rehabilitation of the dental arcades through conjunct gnato-prosthetic devices. The functions of the dento-maxilar device, disturbed by the presence of edentation, require a treatment approach so that, without pre-planning or estimating, the result can lead most of the times to failure in terms of functionality. Clinical evaluation associated with pre- and proprosthetic treatment can also impose, in some situations the evaluation of the dental units involved in prosthetic rehabilitation. The association and implementation of the prosthetic construction in the occlusive-articular ensemble, as well as the counterbalancing of the mastication forces per dental unit and whole interarch system, linked to the distribution of the forces at the level of the pillar teeth and prosthetic construction, represent the goal of this theoretical study.

KEYWORDS: *mastication force, dental occlusion, occlusive mechanics*

Introduction

The association of the occlusive parameters of natural teeth with the occlusive parameters that can be obtained with the conjunct gnato-prosthetic devices, for a variety of edentation types, represent a starting point in the evaluation of the prosthetic treatment [3,4]. The colligation of the data obtained through an occlusive examination with the protocol of evaluation on force distribution within the pale of occlusive mechanics, will enable the planning and realization of the prosthetic construction design.

The present study has as a purpose to praise the role of choosing pillar teeth when it comes to a conjunct denture, which depends on the distribution of masticatory forces on them, depending on the occlusive morphology.

Material and Method

Through this theoretical study we will try to analyze the forces that are transmitted in the vertical ax of the tooth, in the lateral zone of the maxillary, at the level of the premolar(bicuspid) 1-14, bicuspid 2-15, molar 1-16, molar 2-17, molar 3-18, and then we will combine the forces that are transmitted at radicular level in the case of a conjunct prosthetic piece.

According to the length and the position of the edentate breach, we will study the following clinical possible situations: 14 X X X 18; 14 15 X X 18 ; 14 15 16 X 18 ; 14 X 16 17 18; 14 X X 17 18 ; 14 15 X 17 18 ; 14 X 17 X 18.

We will try to obtain general formulas so that we can apply them to the particularities of the 5 studied teeth. For each tooth we will determine the module and direction of the force that is exercised on the function. Keeping the notations, the entry variables which differ, are the length of the cusped slope (further noted with α), the length of the deck zone afferent to every tooth (noted with), the module of the applied force.

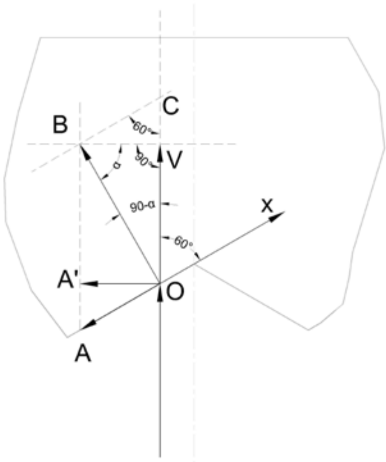

Figure 1- The decomposition of the resulted force

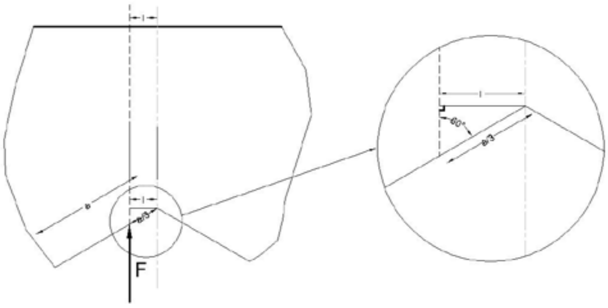

Figure 2- Identification of the force application point

According to the theory, we will start from the following formula:

$$OB^2 = OA^2 + OC^2 - 2 \cdot OA \cdot OC \cdot \sin 60^\circ$$

In the two pictures, we have the following information:

$O'C' = OC = \overline{F}$, where F is the applied force.

$$O'A' = OA$$

We consider the friction coefficient *coef = 0,2.*

$$O'A' = coef \cdot O'B'$$

$$O'B' = O'C' \cdot \sin 60^\circ$$

Replacing in formula 4.   O'B' .

According to the formula 5, we obtain:

$O'A' = coef \cdot O'C' \cdot \sin 60^\circ$,

and taking into consideration formula 3,

$$OA = coef \cdot OC \cdot \sin 60^\circ$$

Replacing in formula 1. The variables according to formulas 2 and 6, we obtain:

$$OB^2 = (coef \cdot OC \cdot \sin 60^\circ)^2 + OC^2 - 2 \cdot OA \cdot OC \cdot \cos 60^\circ$$

$$OB^2 = (coef \cdot OC \cdot \sin 60)^2 + OC^2 - 2 \cdot coef \cdot OC \cdot \sin 60^\circ \cdot OC \cdot \cos 60^\circ$$

$$OB^2 = coef^2 \cdot OC^2 \cdot \sin 60^2 + OC^2 - 2 \cdot coef \cdot OC^2 \cdot \sin 60^\circ \cdot \cos 60^\circ$$

$$OB^2 = OC^2(coef^2 \cdot \sin 60^{\circ 2} + 1 - 2 \cdot coef \cdot \sin 60^\circ \cdot \cos 60^\circ)$$

$$OB = OC\sqrt{0,2^2 \cdot 0,87^2 + 1 - 2 \cdot 0,2 \cdot 0,87 \cdot 0,5}$$

Base formula:

$\underline{OB = OC \cdot 0,925}$,

We can conclude that the module of the resultant force represents 92,5 % of the module of the applied force.

Next we will study the decomposition of the resultant force into two components, one vertical and one horizontal, to determine the module of the force that acts directly on the dental slope (vertical component). From figure 1 we identify the following relation:

$\frac{OV}{\sin\alpha} = OB$, =>

$\underline{OV = OB \cdot \sin\alpha}$

In order to find the value of α , we will find the value of $\underline{\cos\alpha}$. In the BOC triangle:

$$\frac{BC}{\sin(90^\circ - \alpha)} = \frac{OB}{\sin 60^\circ}$$

$$\sin(90 - \alpha) = \frac{\sin 60 \cdot BC}{OB}$$

BC=OA

$$\sin(90 - \alpha) = \cos\alpha$$

$$\cos\alpha = \frac{\sin 60 \cdot OA}{OB}$$

$$\cos\alpha = \frac{\sin 60 \cdot coef \cdot O'C' \cdot \sin 60^\circ}{OC \cdot 0.925}$$

$\cos\alpha = \frac{(\sin 60)^2 \cdot 0.2}{0.925}$ $=> \alpha = 80.67^O$

sin(80.67*)= 0.98 =>*

$\underline{OV = OB \cdot 0,98}$

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The distribution of force on the support points of the deck will be inversely proportional to the distance between the point of its pplication and the extreme vicinity of the support.

To identify the point of application of force will study the figure 2 we have the following notations:

l - distance between the tooth axis and the point of application of force

a - length of the cusped slope

$$\frac{l}{\sin 60} = \frac{a/3}{\sin 90}$$

$$l = a/3 \cdot \sin 60$$

Results

Mean after which conducted the study are evaluated and accepted morphological measurements reported by specialty literature. The results are shown for each of the teeth engaged in the study.

For first premolar
Mesial-distal distance of 7 mm
Cusped slope of 3.25mm
The amount of force applied to the teeth is 15 kgf
The angle α = 600

$$OB_{pm1} = OC_{pm1} \cdot 0{,}925$$

$$=> \boldsymbol{OB_{pm1} = 13{,}875}$$

$$F_{pm1} = OB_{pm1} \cdot 0.98$$

$$=> \boldsymbol{F_{pm1} = 13.59}$$

$$l_{pm1} = 3.25/3 \cdot \sin 60$$

$$=> \boldsymbol{l_{pm1} = 0.94}$$

For second premolars
Mesial-distal distance of 7mm
Cusped slope of 4 mm
The amount of force applied to the teeth is 15 kgf
The angle α = 60

$$OB_{pm2} = OC_{pm2} \cdot 0{,}925$$

$$=> \boldsymbol{OB_{pm2} = 13{,}875}$$

$$F_{pm2} = OB_{pm2} \cdot 0.98$$

$$=> \boldsymbol{F_{pm2} = 13.59}$$

$$l_{pm2} = 4/3 \cdot \sin 60$$

$$=> \boldsymbol{l_{pm2} = 1.15}$$

For first molar
Mesial-distal distance of 9mm
Cusped slope of 4.5 mm
The amount of force applied to the teeth is 19 kgf
The angle α = 60

$$OB_{m1} = OC_{m1} \cdot 0{,}925$$

$$=> \boldsymbol{OB_{m1} = 17.575}$$

$$F_{m1} = OB_{m1} \cdot 0.98$$

$$=> \boldsymbol{F_{m1} = 17.22}$$

$$l_{m1} = 4.5/3 \cdot \sin 60$$

$$=> \boldsymbol{l_{m1} = 1.29}$$

For second molar
Mesial-distal distance of 10.5mm
Cusped slope 5mm
The amount of force applied to the teeth is 19 kgf.
The angle α = 60^0

$$OB_{m2} = OC_{m2} \cdot 0{,}925$$

$$=> \boldsymbol{OB_{m2} = 17.575}$$

$$F_{m2} = OB_{m2} \cdot 0.98$$

$$=> \boldsymbol{F_{m2} = 17.22}$$

$$l_{m2} = 5/3 \cdot \sin 60$$

$$=> \boldsymbol{l_{m2} = 1.44}$$

For third molar
Mesial-distal distance of 10mm
Cusped slope of 4.5 mm
The amount of force applied to the teeth is 21 kgf

$$OB_{m3} = OC_{m3} \cdot 0{,}925$$

$$=> \boldsymbol{OB_{m3} = 19.425}$$

$$F_{m3} = OB_{m3} \cdot 0.98 => \boldsymbol{F_{m3} = 19.03}$$

$$l_{m3} = 4.5/3 \cdot \sin 60 => \boldsymbol{l_{m3} = 1.29}$$

The study of the established clinical situations by the original protocol are shown in Figure 3.

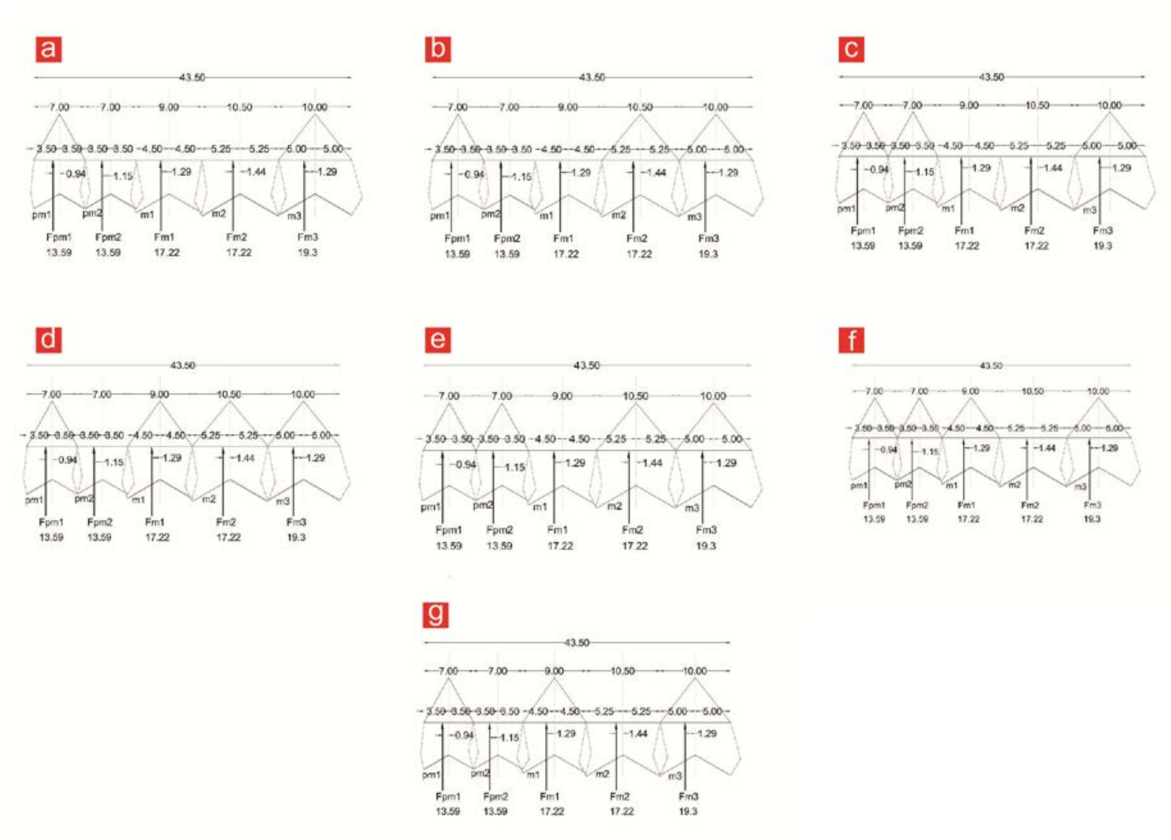

Figure 3- Edentulous interlaced versions accepted in the study

Situation 1.
The bridge has as a pillar teeth the premolar 1 and molar 3
The toothless gap is given by the premolar 2, molar 1 and molar 2:

The force supported by premolar 1 is equal to: FT_{pm1}=43,43
The force supported by molar 3 is equal to: FT_{m3}=37,48
b.Situation 2
The bridge has as a pillar teeth the premolar 1 and molar 2
The toothless gap is given by the premolar 2 and molar 1:

The force supported by premolar 1 is equal to:FT_{pm1} = 31,41
The force supported by molar 2 is equal to: FT_{m2}= 30,21
c. Situation 3

The bridge has as a pillar teeth the premolar 2 and molar 3
The toothless gap is given bythe molar 1 and molar 2

The force supported by premolar 2 is equal to: FT_{pm2} = 33,87
The force supported by molar 3 is equal to: FT_{m3}= 33,46
d. Situation 4

The bridge has as a pillar teeth the premolar 1 and molar 1
The toothless gap is given by the premolar 2
The force supported by premolar 1 is equal to: FT_{pm1} = 22,86
The force supported by molar 1 is equal to: FT_{m1}= 21,54

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e. Situation 5

The bridge has as a pillar teeth the premolar 2 and molar 2
The toothless gap is given by the molar 1

The force supported by premolar 2 is equal to: FT_{pm2} = 24,66
The force supported by molar 2 is equal to:FT_{m2}= 23,37

f. Situation 6

The bridge has as a pillar teeth the molar 1 and molar 3
The toothless gap is given by molar 2
The force supported by molar 1 is equal to cu:FT_{m1} = 28,19
The force supported by molar 3 is equal to:FT_{m3}= 25,55

g. Situation 7

The bridge has as a pillar teeth the premolar1, molarl 1 and molar 3
The toothless gap is given by the premolar 2 and molar 2
The force supported by molar 1 is equal to cu:FT_{pm1} = 22,86
The force supported by molar 1 is equal to:FT_{m1} = 32,75
The force supported by molar 3 is equal to:FT_{m3}= 25,55

Based on the maximum values of the vertical pressure supported by the teeth and periodontal (premolar I - 44 kg, premolar II - 44 kg, mol I - 45-70 kg, molar II - 45-70 kg, molar III - 64 kg) and taking into account that in chewing there are commonly used about 1/3 of the maximum force values we calculated the vertical forces supported by pillar teeth in the possible situations op conjunct restoration for maxillary lateral area.

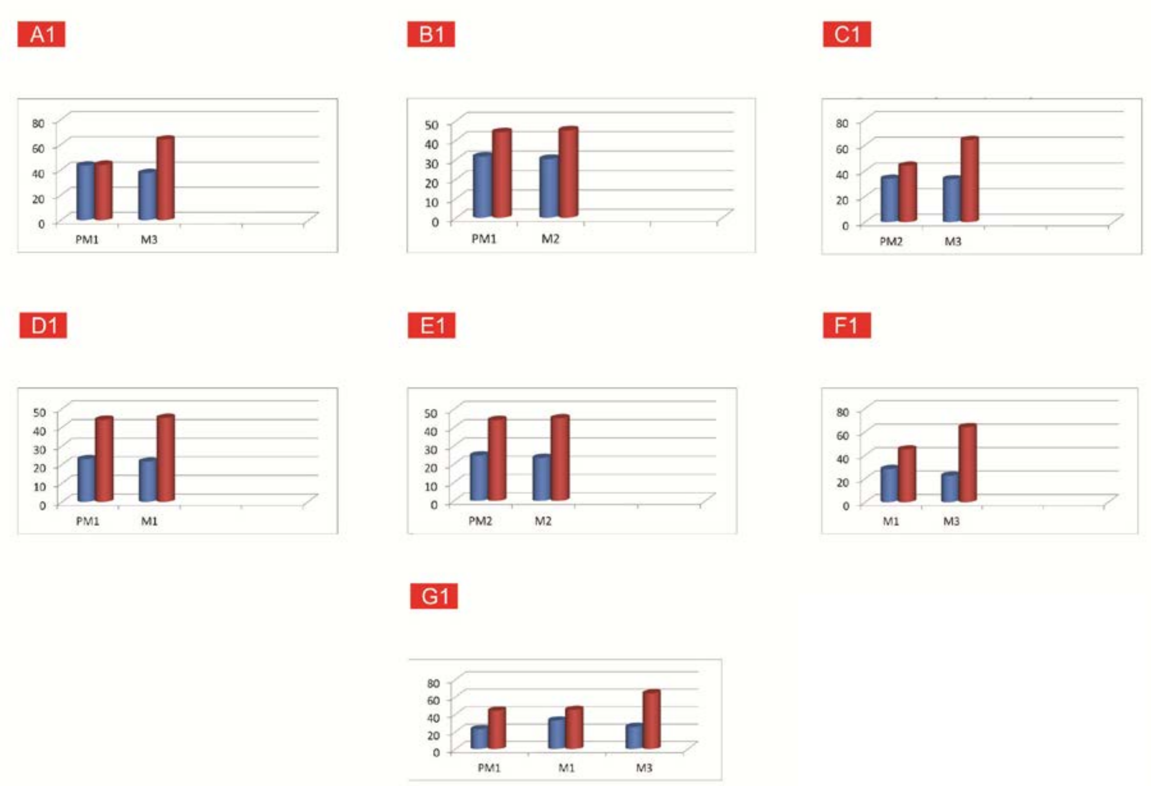

Figure 4- The forces exerted on the bridge abutments in clinical situations set to be studied

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A1. In situation 1 when we have 14 X X X 18 - The force supported by the premolar 1 is 43,43 kgf ,lower than the maximum support capacity of the tooth =44 kgf and the force supported by the molar 3 is equal to 37.48 kgf when the maximum support capacity of the tooth is = 64 kgf.

B1. In situation 2 when we have 14 X X 17 18 - The force supported by the premolar 1 is 31,41 kgf, lower than the maximum support capacity of the tooth = 44 kgf and the force supported by the molar 2 is equal to molar 3 equal to 37,48 kgf when the maximum support capacity of the tooth is 64 kgf.

C1. In situation 3 when we have 14 15 X X 18 - The force supported by the premolar 2 is 33,87 kgf, lower than the maximum support capacity of the tooth =44 kgf and the force supported by the molar 3 is equal to 33,46 kgf when the maximum support capacity of the tooth is 64 kgf.

D1. In situation 4 when we have 14 X 16 17 18 - The force supported by the premolar 1 =22,86 kgf lower than the maximum support of the tooth =44 kgf and force supported by molar 3 is equal to 21,54 kgf when the maximum support capacity of the tooth is 45-70 kgf.

E1. In situation 5 when we have 14 15 X 17 18 - The force supported by the premolar 2 = 24,66 kgf is lower than the maximum support capacityof the tooth= 44 kgf and the force supported by the molar 2 is equal to 23,37 kgf when the maximum support capacity of the tooth is 45-70 kgf.

F1. In situation 6 when we have 14 15 16 X 18 - The force supported by the molar 1 de 28,19 kgf is lower than the maximum support capacity of the tooth =45-70 kgf and the force supported by molar 3 is equal to 25,55 kgf when the maximum support capacity of the tooth is 64 kgf.

G1. In situation 7 when we have 14 X 16 X 18 - The force supported by the premolar 1 = 22, 86 kgf is lower than the maximum support capacity of the tooth =44 kgf, the force supported by the molar 1 is equal to 32,75 kgf when the force supported by the molar 3 is equal to 45-70 kgf and the force supported by the molar 3 is equal to 25,55 kgf when the maximum support capacity of the tooth is 64 kgf.

Discussions

In a normal mastication in all the cases of conjunct prosthetic the cumulative values of the vertical forces given by the artificial teeth can be supported by the pillar teeth [5,6].

In situation number 1 in a normal mastication when we as pillars the premolar1 and the molar 3, and toothless gap is given by premolar 2, molar 1 and molar 2, vertical forces given by toothless gap that are transmitted in the long axis of the premolar1(one pillar tooth) are very close to its maximum capacity support (43,43 kgf capacity calculated ≤ 44 kgf maximum capacity)which leads to the idea that the treatment option is a mistake. Since the study was done in the case of medium mastication in a clinical situation the possibility of adding another pillar tooth is taken into consideration. Morphology prosthesis also requires a reduction in the height and slope inclination cuspidiene while shaping a body of deck width buccolingually reduced. Occlusal rebalancing is a mandatory step that contributes to integration biological dental bridge.

The other situations may represent prosthetic solutions with the condition that the occlusal morphology allow the dispers of the horizontal, vertical and oblique components given by a force acting on this surface [7,8].

Conclusion

The understanding of the occlusal morphology as a variable and ready to be improved support in making prosthesis can balance and harmonize the forces that can act at this level.

Acknowledgements

All authors contributed equally to this study.

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