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Preliminary Design for Orthodontic Bracket Holder

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Abstract

The process of placing the brackets in their proper positions in the field of orthodontics is consider one of the main steps in orthodontic treatment. In order to achieve high accuracy placements for the brackets, many methods are available today, starting from direct and indirect methods, each of them has advantages and disadvantages regarding the accuracy and the time for patient treatment. In this study, a new mechanism is introduced with its mechanical behavior in order to reduce the time required for patient treatment and to increase the accuracy for bracket placements. The newly mechanism was designed using Solid works CAD software with a total Virtual functionality for all of the parts of the assembly, then a simulation was carried out to find the stress distribution, deformation, and strain on the main parts of the proposed assembly. The finished design shows a high precision mechanism that is able to place brackets one by one on the teeth.

Keywords: Orthodontics, Brackets, Direct Bonding, Indirect Bonding, Semi-Automatic, Orthodontic Mechanism.

التصميم الاولي لأداة حمل دعامات تقويم الاسنان

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الخلاصة:

تعتبر عملية وضع دعامات تقويم الاسنان في مواضعها الصحيحة احدى الخطوات الرئيسية في علاج تقويم الاسنان ومن اجل تحقيق مواضع عالية الدقة هنالك العديد من الطرق منا التقنيات المباشرة والغير مباشرة ولكن لكل منها ميزات وعيوب فيما يتعلق بالدقة ووقت علاج المريض. في هذه الدراسة تم ادخال الية ميكانيكية جديدة تجمع بين الطريقتين لتقليل الوقت اللازم لعلاج المريض وزيادة الدقة في وضع الدعامات. التقنية الجديدة صممت باستخدام برنامج سوولدورك ثم تم اجراء تحليل لتحديد مواقع توزيع الاجهادات والتشوه والضغط على الأجزاء الرئيسية للتصميم. التصميم النهائي يظهر الية عالية الدقة قادرة على تثبيت الدعامات واحدة تلو الأخرى على الاسنان.

1- Introduction:

Orthodontic treatment plays a crucial role in enhancing oral health, aesthetics, and overall quality of life. It offers a range of treatment options to suit individual needs and addresses issues related to misaligned teeth and jaws. With its potential to improve self-confidence, speech, eating habits, and long-term oral health, orthodontic treatment is a valuable investment in one's well-being. [1] [2] [3]

Orthodontics is a specialized branch of dentistry focused on correcting misalignments of teeth and jaws.

One key challenge in orthodontic treatment lies in the precise placement of brackets, essential components that facilitate tooth movement. Accurate bracket positioning is paramount for optimal alignment and bite correction. Misplaced brackets can result in treatment inefficiency, prolonged duration, and discomfort for the patient. Orthodontists employ meticulous planning, advanced technology, and their expertise to ensure brackets are affixed correctly. Technological advancements, such as 3D imaging and computer-aided design, have enhanced precision, aiding orthodontists in overcoming the challenge of bracket placement for more effective and streamlined orthodontic care. In this research focuses on designing a new orthodontic bracket holder, as new way of bonding. This Study presents a new semi-automatic bonding method, in which the disadvantages of the other bonding methods are corrected in this design [4] [5] [6].In this study two different goals are placed. The first goal was to design a 3D model that presents a new mechanism used to facilitate the operation of placing the brackets on the tooth surface in their right place in a semi-automatic manner, i.e. the operator will do most of the preparation prior the patient final visit. The second is to simulate the design using a simulation software to investigate the locations of stress concentrations and maximum stresses and strains as well as the deflection that may accrue to some of the

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parts under the load. The successful alignment of teeth and correction of malocclusions depend on the precise interaction and coordination of these fixed orthodontic components. Orthodontists carefully assess each patient's needs and select the appropriate components and techniques to create a treatment plan tailored to their unique situation. [7] [8] [9].

2. Materials and Methods:

The preliminary design is composed of about 25 parts, these parts are grouped in sub-assemblies and then in the final assembly of the final design for six teeth.

In this heading, each of the parts will be presented individually. It should be noted that the (25) parts have replicates, so that only the unique parts will be presented:

The ball and socket part:

This part represents the main part in the mechanisms, it shown in figures (1) and (2).

At the start, it has a hollow part the offer to the operator to slide the slider part of the mechanism. In addition, this part has a solid ball at the end that fit in the socket to adjust the direction movement (up, down, right and left) in desired place.

Figure (1): the ball part that move in the four directions

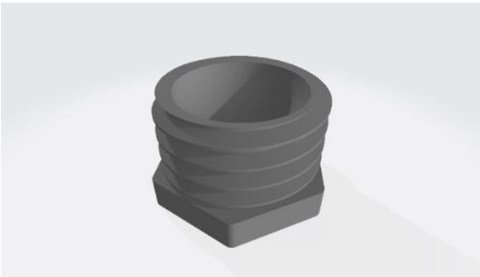

Figure (2): the socket part that acts as a joint with the ball part

The cover part:

This part is act as a complementary to the previous part, it shown in figure (3).

It acts as a cover to the ball and socket joint to fix the direction of the joint.

Figure (3): the complementary cover part

The slider part:

This part inserted inside the cavitation of the ball and socket joint to allow a slider movement in the anterior and posterior direction of the tool. At the end of this part, the brackets are mounted as shown in figure (4).

Figure (4): the slider part

The main base

This part act as a base to mounted all the previous parts. i.e this base able to deal with the six teeth at the same time.

3. The Designed Mechanism:

The final design is constructed from all of the previous parts and sub-assemblies, some of them has been duplicated (repeated) like the bracket holder, it has been repeated six times (as the number of teeth that this mechanism can handle). CAD technology allows for highly aesthetic outcomes in orthodontics and restorative dentistry, enhancing the patient's smile. [10] [11] [12]

The main boundary conditions that constraints the design is the oral vestibule, which is a fundamental structure within the mouth that facilitates important functions such as mastication, speech, and swallowing. It also contributes significantly to oral health and the stability of dental prosthetics. [13] [14] [15]

It is essential for orthodontists to have a high level of precision and attention to detail during the bracket placement process. Accurate bracket positioning contributes to successful treatment outcomes, faster tooth movement, and reduced treatment time. Advanced technologies, such as computer-aided bracket placement (CAD/CAM), may also be used in some orthodontic practices to enhance accuracy and efficiency. [16] [17].

The final design is shown in figures (5) and Figure (6). This sub-assembly used to hold the bracket on one hand, and on the other hand is used to provide all of the movements (degrees of freedom) for the bracket to be placed in its proper position. The bracket holder sub-assembly is shown in figure (7).

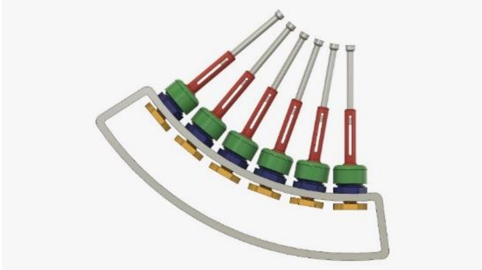

Figure (5): the design assembly

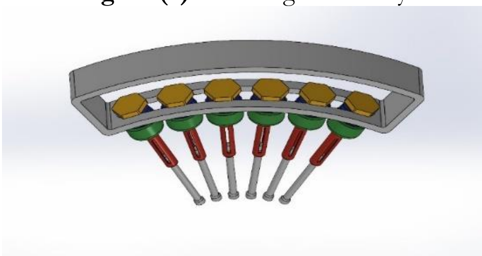

Figure (6): the design second assembly

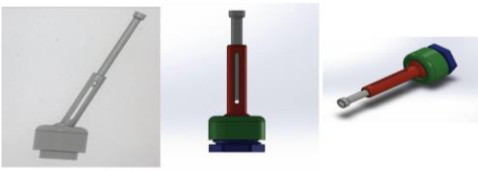

Figure (7): Bracket holder sub-assembly

4. Results:

By using ANSYS 2022 to establish simulations runs against selected parts of the design, many plots were generated, each plot generated against the forced applied to the tool by the dentist

- "P2-Total Deformation" against "force" is the first plot and is shown in figure (8) , as shown with increasing the force the total deformation increased.

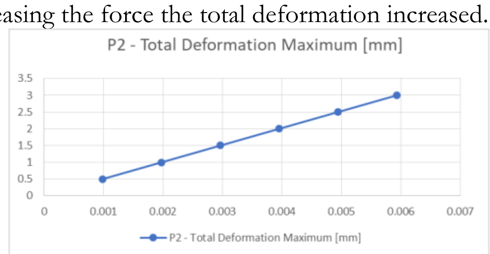

Figure (8): Total deformation

-P3 – Equivalent Elastic Strain

-P3- Equivalent Elastic Strain against force is the second plot and is shown in Figure (9), as shown with increasing the force Equivalent Elastic Strain increased.

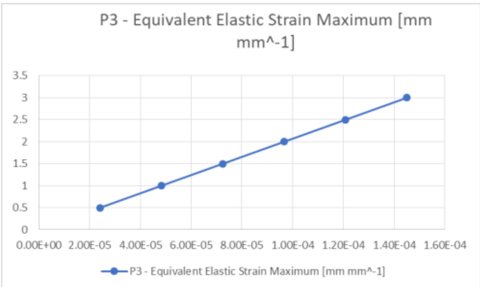

Figure (9): Equivalent Elastic Strain

-P4- Equivalent stress against force is the second plot and is shown in Figure (10), as shown with increasing the force Equivalent stress increased.

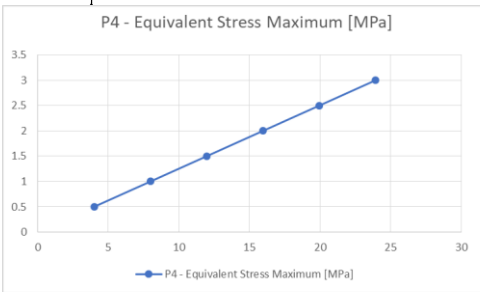

Figure (10): Equivalent stress

-P6- Safety factor against force is the second plot and is shown in Figure (10) , as shown with increasing the force safety factor decreased

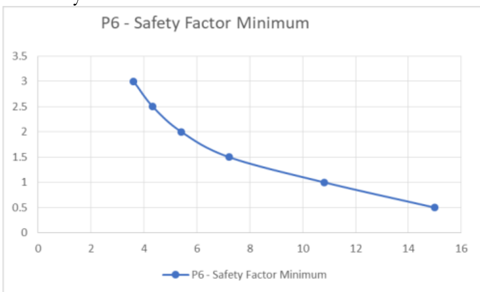

Figure (11): Safety factor

All the plots above considered acceptable according to the applied load as shown in the table below:

Table (1): The magnitude of the force and the result deformation, stress, strain and safety factor

P1 - Force Magnitude [N]	P2 - Total Deformation Maximum [mm]**x10⁻³**	P3 - Equivalent Elastic Strain Maximum [mm/mm]	P4 - Equivalent Stress Maximum [MPa]	P6 - Safety Factor Minimum
0.5	0.989103	2.42E-05	3.985270944	15
1	1.978206	4.84E-05	7.970541888	10.81482303
1.5	2.967309	7.25E-05	11.95581299	7.20988193
2	3.956411	9.67E-05	15.94108376	5.407411523
2.5	4.945514	0.000120903	19.92635474	4.325929209
3	5.934617	0.000145084	23.911626	3.604940961

5. Discussion:

In order to discuss the resulted newly designed mechanism, its performance should be examined virtually in the methods of Simulation using FEM (Finite Element Method). In order to estimate the deformation that will happen in each of the parts, ANSYS 2022 were used to establish simulations runs against selected parts of the design. the software supports compatibility with various file formats, making it suitable for interoperability with other CAD software and manufacturing processes. From another point of view, and in order to view the diversity of the stresses in the parts, the "Stress" option was selected to develop the stress distribution over the volume of the parts. In each of the simulations, a force of $F_t = 50N$ were chosen at the base of the first part.

The force has been applied at the base that transmit the reaction of the tooth to the bracket. And its value was taken to be $50N$. The location of the force and its value is shown in figure (12).

After the definition of the force, the boundary conditions were selected to be fixed at the circular base to mimic the actual situation.

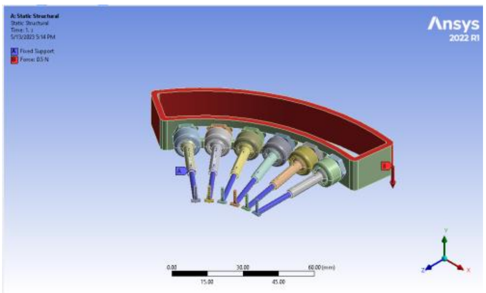

Figure (12): The location of the initial force 50 N

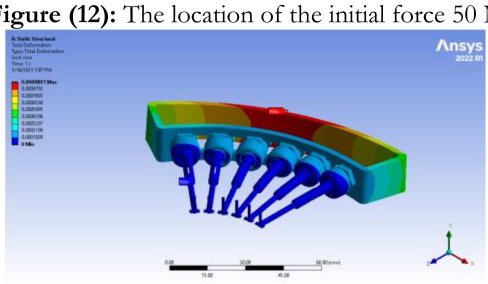

Figure (13): Total Deformation

A minimum deformation of (0 at the end point of tool) and maximum deformation of (0.0009891 mm at the main base if tool).

6. Conclusions

The novel design was enough to describe and to adapt any position (location and orientation) of the tooth. i.e. the bracket holder mechanism was able to deliver the bracket to its right place on the tooth regarding any deformity in the tooth location or orientation. The advantage of the added alignment mechanism (replacing the sixth tooth bracket holders) was to ease the usage of the novel mechanism by the operator and to reduce the experience required to mount this novel mechanism on the right positions on the teeth surfaces. The main base for this novel mechanism is adequate for an adult size mouth, for elder patients, the main base should be made smaller, with using the same bracket holders.

7. References

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