Experimental analysis of stress in teeth with different preparations and discharges.

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Summary

The aim of this study was to observe the behaviour of different gingival endings of the restorations and their significance as support agents, with the addition or not of interradicular reinforcement in relation to the possible variants that may come from internal tensions of the teeth committed by a force.

The approach that determined the line of research through photoelasticity allowed the visualization itself of the forces, for this purpose an experimental prototype was built which faithfully reproduced a restored dental piece exposed to forces of mastication.

The different preparations under similar charges showed different internal grades of tension as indicated by the isochromatic orders, index of the different aptitude to transmit a positive effort according to the case.

The preparations without shoulder and without post were the most favourable for presenting the minor concentration of internal tensions, greater uniformity of compression and traction lines and they also had the most favourable results in terms of stress gradient.

Objectives

To observe the behaviour of the various gingival endings regarding the possible variants that may come from internal tensions of the teeth engaged by a force.

To optimize the design of the different gum reductions and completions.

To analyze the significance of gingival endings as support agents, with the addition or not of interradicular reinforcement.

To compare in the different designs the variation in stress concentration, stress gradients and stress cut and traction.

Discussion and conclusions

In this thesis an experimental investigation was made, on scale models, of the pattern of stress distribution in teeth with various preparations and wear, using the photoelastic technique.

The forces that support the teeth in exercising the functions of chewing, appear applied in different directions and through different inclined planes, which are represented by the facets that make up the occlusal surfaces. Our goal was to analyze the state of internal tension that supports the teeth. We used an optomechanical method known as photoelastic method.

Photoelasticity provides an overview of the state of internal tension of a two-dimensional model subjected to loads at the edges.

The two-dimensional model is always a parallel flat sheet cut of a suitable material, and its profile corresponds to the contour of the transverse plane which divides the piece, designed into a suitable scale (zoomed). In our case it is a model on a larger scale, corresponding to a median palatal premolar vestibule.

The simple observation of the fringe pattern, which shows the analysed photoelastic model, provides important information to predict the critical points of the piece. Indeed, those areas where there is the highest density of isochromatic fringes are considered critical areas, because the stress gradient is very high. In these regions of the model, a strong concentration of stress is produced which can lead to the failure of the piece in those areas.

The study of the isochromatic on photoelastic models with different designs and preparations, applying antagonist increasing loads allowed us to observe how the stresses are distributed within the piece.

Indeed, when a two-dimensional photoelastic model subjected to loads applied perpendicular to its edges is analysed, there is a set of stripes, each of which corresponds to an order (integer). The higher the order of the band analyzed, the higher are the stresses supported by the model along it.

Thus, when a region of the model shows a high density of bands (many stripes, almost parallel, concentrated in a small area) we observe a region with a high stress gradient.

It is easy to deduce that in these cases there is a significant variation in stress along a short circuit. This means that those areas or points of the model have a high stress concentration. If in such areas exist or develop a fault or microcrack in the crystalline structure of the piece, the high concentrations of stress prolonged the crack or failure, reducing the gradient space, which increases correspondingly.

This process continues, rapidly driving the piece to break into the area of high gradient.

As noted by Toyoda, Kasori and Hawa.[30], to know this is very important. It is therefore advisable, if possible, to modify the design of the piece in order to reduce the stress gradient in the risk area.

This study analyzed four models, with parallel loads to their longitudinal axes, applied in Maximum Occlusion and Bite Force, since these are the most physiological forces that support the teeth.

Our results confirm that the concentration of stress that the teeth support vary significantly between different preparations and wear. These results agree with those obtained by the Ebrashi, Craig and Peyton[6].

The different preparations under similar load conditions, showed different internal gradients of tensions, as indicated by the isochromatic orders, index of the different capacity to transmit a positive effort, according to the case.

Preparations which presented lower fringe orders for the same level of applied forces were:

1. In the middle zone:
   a. In the fundamental cusp side, the shoulderless and no pin together with the shoulderless and pin ones
   b. In the no fundamental cusp side the preparations without shoulder and pin.

In that way the preparation with shoulder showed us a greater stress concentration in the middle zone due to this design, both on the fundamental cusp side and on the not fundamental cusp one.

2. in the occlusal contact area of the preparation with the restoration:
   a. At the fundamental cusp side, the no pin and with shoulder ones.
   b. At the no fundamental cusp side, the no pin and shoulderless ones.

The lowest strip order in these preparations showed us that the support of the restoration on the preparation is not only given by the occlusal contact area, but also by the support area of the shoulder.

Therefore shoulderless and pinless preparations in this area of the occlusal surface showed a less favourable state of stress.

3. In the shoulder area:
   a. At the fundamental cusp side, the with-pin and shoulderless ones.
   b. At the side of not fundamental cusp, the pinless and shoulderless ones.

Our results are consistent with those presented earlier by other researchers.[5.6]

4. In the area of the apical end, there were the preparations without pin and with shoulder the ones which had lower fringe orders.

From Table No. 7.2 the really significant values of stress gradient were calculated.

a. Comparison of σ gradient values in both models, in Section 1-1, the preparation S / H and S / P was pointed as the best conditioned.
b. Similar comparison for 2σ, in section 2-2', showed the preparations with shoulder and pin as the ones with more favourable design. But instead, tensions flowed more evenly in the preparations S / H and S / P, as shown by the analysis of the isostatic.Taking into account the claims of Ohyama T[31], these designs and preparations should be considered for an appropriate distribution of functional stresses.
   Besides, these shoulderless designs less compromise the pulpal structure without diminishing the support, so that they agree with Seymour K, Zou L, Samarawickrama DYD and 32 Linch E.
c. With regard to section 3-3', the gradients were very high for both strains so the design in this condition is unfavourable.
d. Similar result was observed in section 4-4'.

The findings obtained in this study indicated that certain designs optimize the stress state. The presence of a pin stump and shoulder disadvantage the biomechanical behaviour of the preparations, as detailed in the following paragraphs. According to these results, the different designs were ordered, based on their state of stress concentration.

Probably, our results are not just a device linked to methodology; however we recognize that the study was limited to two-dimensional stress analysis. Therefore, we leave the possibility or not of correspondence between two-and three-dimensional similar models open.

Conclusions:

Shoulderless and pinless preparations are the most favourable as they show less internal tensions concentrations.

Shoulderless and pinless are the most favourable as they show greater uniformity in the delineation of compression and traction lines.

The preparations with shoulder presented unfavourably oriented traction stress, which induces the formation of cracks.

The shoulderless and pinless preparations are those with the most favourable results in terms of stress gradient.

Taking into account the C and D given observations raised in the discussion of quantitative analysis of principal stresses, we must consider carefully the choice of designs with shoulder and pin and monitor their implementation to avert any possibility of cracking or splitting.