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INDIRECT RETENTION REVISITED: RISKS, BENEFITS AND PARADIGM-SHIFT IN REMOVABLE PARTIAL DENTURES

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ABSTRACT

The clinical success of removable partial denture (RPD) relies on the widely stablished biomechanical principles of retention, stability and support. In contemporary approaches, however, open prosthetic designs with minimal oral tissues coverage have been advocated. Longstanding conflicting opinions regarding the indirect retention concept have arisen, although robust scientific evidence is still scarce. To shed some light on this issue, the current work aimed at *in vitro* analyzing the influence of indirect retainers in the forces transmitted to abutment teeth of a unilateral distal extension mandibular RPD.

Keywords: Removable partial dentures (RPD), retainers, finite element method (FEM).

INTRODUCTION

Removable partial denture (RPD) still plays a pivotal role in conventional oral rehabilitation, representing a noninvasive and less expensive treatment option in comparison to other current solutions [1, 2]. Classical theories for RPD design have focused on the biomechanical aspects of force distribution, support, stability and retention [3]. Despite widely disseminated, these principles lack scientific evidence [1, 2]. The importance of adequate plaque control and protection of oral tissues, as well as simple and open designs with minimal coverage of surface area have been advocated by contemporary RPD strategies [4, 5].

While routinely used in free-end saddle dentures, indirect retainers are not without criticism. Primarily designed to counteract the rotational displacement of distal extensions about a fulcrum axis, these elements play complementary functions related to increased stability against horizontal movements, additional guiding surfaces, reduced anteroposterior lever action on abutment teeth and stress distribution [6]. Nonetheless, a set of arguments questioning the value of indirect retention, namely its effectiveness in preventing the lifting of distal bases under masticatory forces and the need of averting torque forces transmitted to abutment teeth, has been presented elsewhere [7, 8].

The controversy described above prompted us to experimentally appraise the importance of indirect retention on the biomechanical performance of a distal extension RPD. Using an *in vitro* model of a mandibular Kennedy class II prosthesis and taking advantage of an Electronic Speckle Pattern Interferometry (ESPI) setup, this work aimed at investigating the forces transmitted to the abutment teeth – of both direct and indirect retainers – in the presence and absence of indirect retention.

MATERIAL AND METHODS

Mandibular model

To simulate the mandibular arch, a standard acrylic model (Frasaco, Tettnang, Germany) was used. Teeth 35, 36, 37, 38 and 48 were removed and the corresponding regions covered with a thin layer of putty addition silicone (Virtual Fast Set, Ivoclar Vivadent, NY, USA; Fig. 1A-C). Spoon-shaped occlusal rests, designed as *per* the Principles, Concepts and Practices in Prosthodontics (1994) guidelines [3], were prepared in teeth 35 (*mesial*), 46 (*distal*) and 47 (*mesial*). A small rest seat was cut in the 44 mesial marginal ridge to accommodate (if necessary) the indirect retainer. All teeth preparations were performed with 016 and 018 diamond round burs used with a high-speed handpiece. The model was duplicated using a standard impression tray loaded with alginate material, being the gypsum cast immediately obtained.

Mandibular RPDs

Two Kennedy class II RPDs fabricated of acrylic resin with a cobalt-chromium alloy framework were casted on the acrylic model. Both prostheses consist of the following components: a) a lingual bar (major connector); b) a circumferential clasp in tooth 34 and a double Akers clasp in 46 and 47 (direct retainers); c) three occlusal rests on the abutment teeth 34 (*mesial*), 46 (*distal*) and 47 (*mesial*) to support direct retainers and d) prosthetic teeth 35, 36, 37 and 48. The two RPD frameworks were only distinguished by the presence (IR model) or absence (noIR model) of an indirect retainer on tooth 44 (Figure 1).

Fig. 1 - Fabricated RPDs placed on the acrylic mandibular model. A and B, RPD with an indirect retainer on teeth 44 (IR, different views). C and D, RPD without indirect retention elements (noIR, different views).

ESPI model system

To analyze the displacement pattern induced by an applied load to the abutment teeth in the presence and absence of indirect retention, an ESPI-based setup was developed. Using coherent light illumination, the ESPI technique enables interferometric measurements of surface displacements or strains, with no direct contact with the object and submicrometer resolution [9, 10]. Upon immobilization of the mandibular model, tensile forces perpendicular

to the occlusal plane ranging from 0,15 to 0,70 N, were delivered on the distal aspect of the free-end saddle. Fig. 2 shows the ESPI setup used to measure the out-of-plane displacement field. Briefly, a Coherent Verdi 532 nm laser (2 W) beam was split into two beams of equal intensity (reference and object beams). The interference between the two wave fronts results in a set of interferometric fringes corresponding to a holographic recording, what means the registration of the amplitude and phase of the wave front coming from the object. This means that the difference between an initial state (no load) and a final state (load) results in a fringe pattern, being these fringes related to the displacement isocurves. Using a phase shift element (mirror + Piezoelectric device - PZT) and with an appropriated algorithm it is possible to calculate the phase maps, suitable for data post-processing. From these phase maps is possible to assess the displacement field knowing the laser wavelength and the setup geometry. Upon confirming the reproducibility of the tensile forces applied, a single measurement was recorded for each experimental condition. To minimize potential confounding variables, the indirect retention element was removed from the RDP after concluding the IR-related assays, and thus used as noIR model.

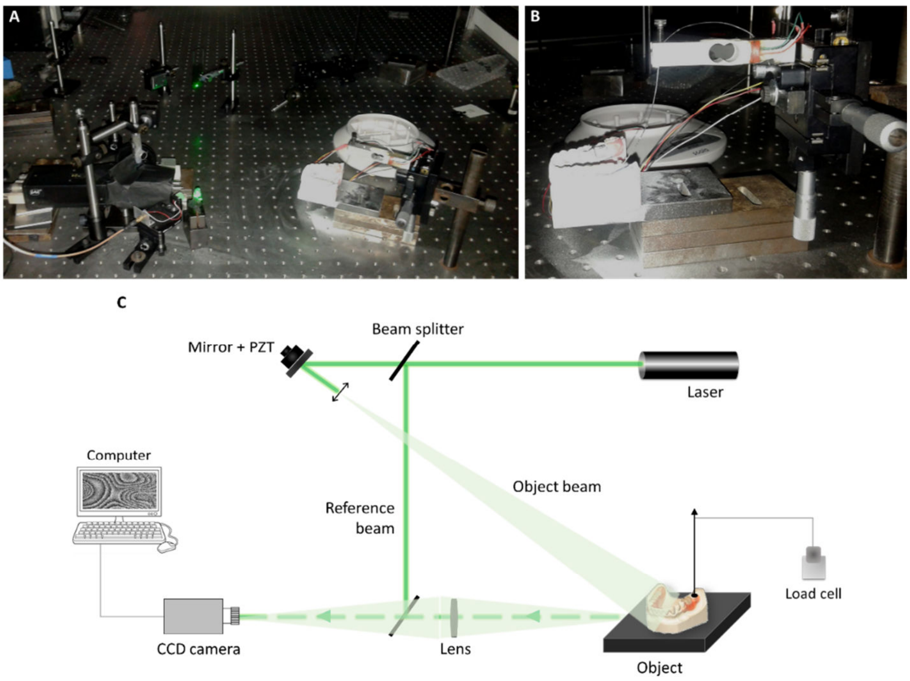

Fig. 2 - Experimental ESPI setup for measurement of the surface displacements (out-of-plane displacement field). A, Photograph of the experimental setup. B, Detail of the experimental system showing the point of application of tensile forces in the RPD. C, Schematic representation of the experimental setup. PZT – Piezoelectric device. CCD – Charge-Coupled Device.

RESULTS AND DISCUSSION

Since interferometric measurements are obtained upon illuminating the surface of the test object with laser light, data from the third and fourth quadrants was separately collected. The out-of-plane displacements registered for each experimental group and condition are summarized in Figs. 3 and 4. According to the obtained results, the deformation magnitude of the abutment tooth adjacent to the edentulous ridge in the presence or absence of an indirect retainer depends on the intensity of the tensile force applied. Under low intensity dislodging forces (Fig. 3A vs Fig. 4A) able to trigger the retentive function of the direct retainer clasp, the presence of the indirect retainer guarantees an additional fulcrum point that might attenuate forces transmitted to the principal abutment. On the contrary, in the context of higher tensile forces (Fig. 5B vs Fig. 6B), the deformation resistance of the clasp is likely surpassed. If no indirect retention were provided, the retentive portions of the direct retainers become the only rotation points for the RPD [6]. It is conceivable, therefore, that during the occlusally-directed rotation path, retentive clasps were displaced from the tooth, thus justifying the diminished deformation of the corresponding abutment.

The increased deformation of the contralateral abutment tooth in the presence of indirect retention (compare Fig. 4C vs Fig. 3C and Fig. 4D vs Fig. 3D), corroborates the notion that indirect retainers facilitate stress distribution [6]. The herein presented findings also highlight the impact of dislodging forces on the tooth supporting the indirect retention element, whose long-term benefits and disadvantages should be carefully analyzed as suggested by others [7].

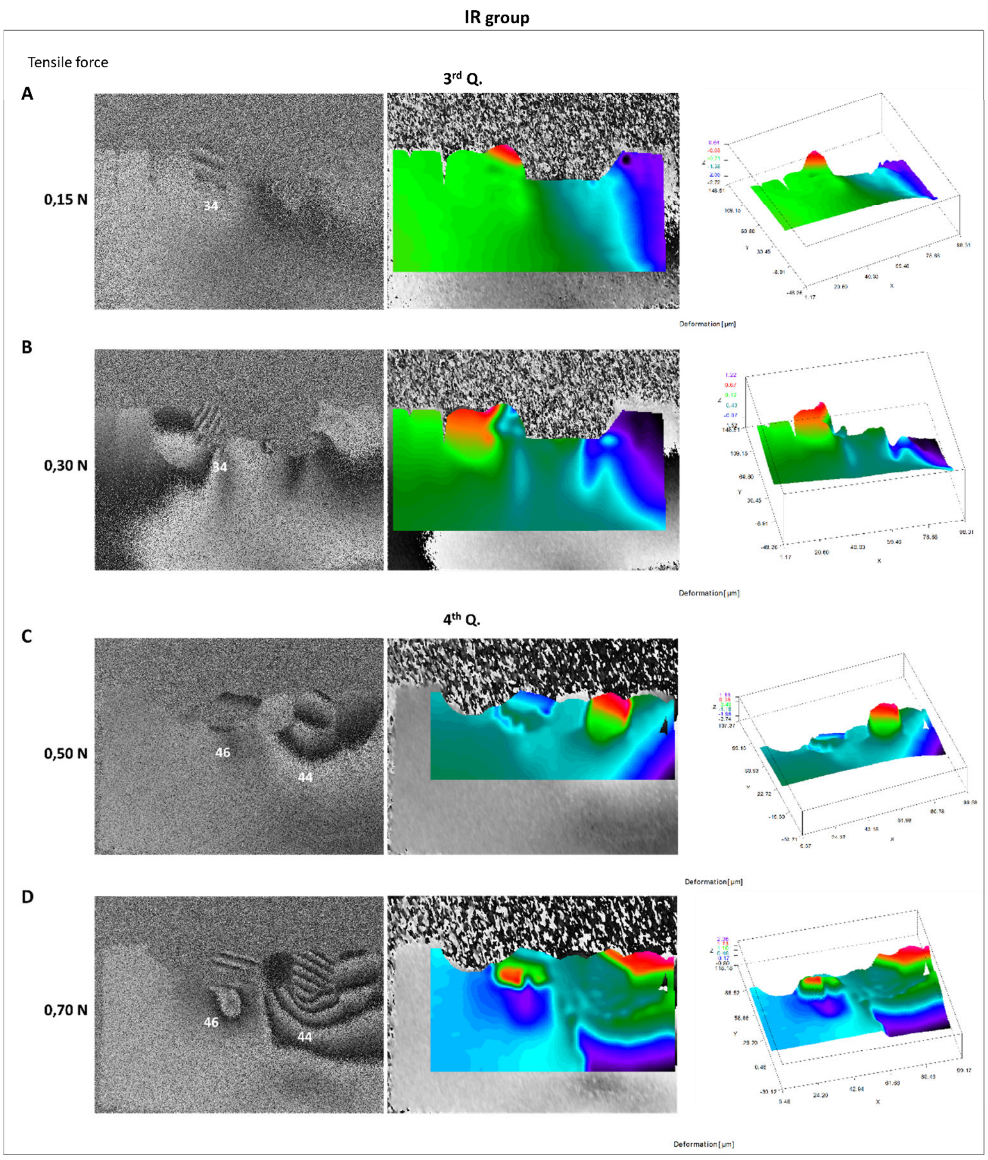

Fig. 3 - ESPI measurements for the indirect retention (IR) group upon application of a tensile force in the free-end saddle (out-of-plane displacement field). Raw fringe pattern, with tooth numbers depicted (left); filtered phase map image, color-coded (middle): red – highest displacement; blue – lowest displacement;

graphical representation of the final 3D displacement values (right). A and B, Records for the third quadrant (3rd Q.). C and D, Records for the fourth quadrant (4th Q.).

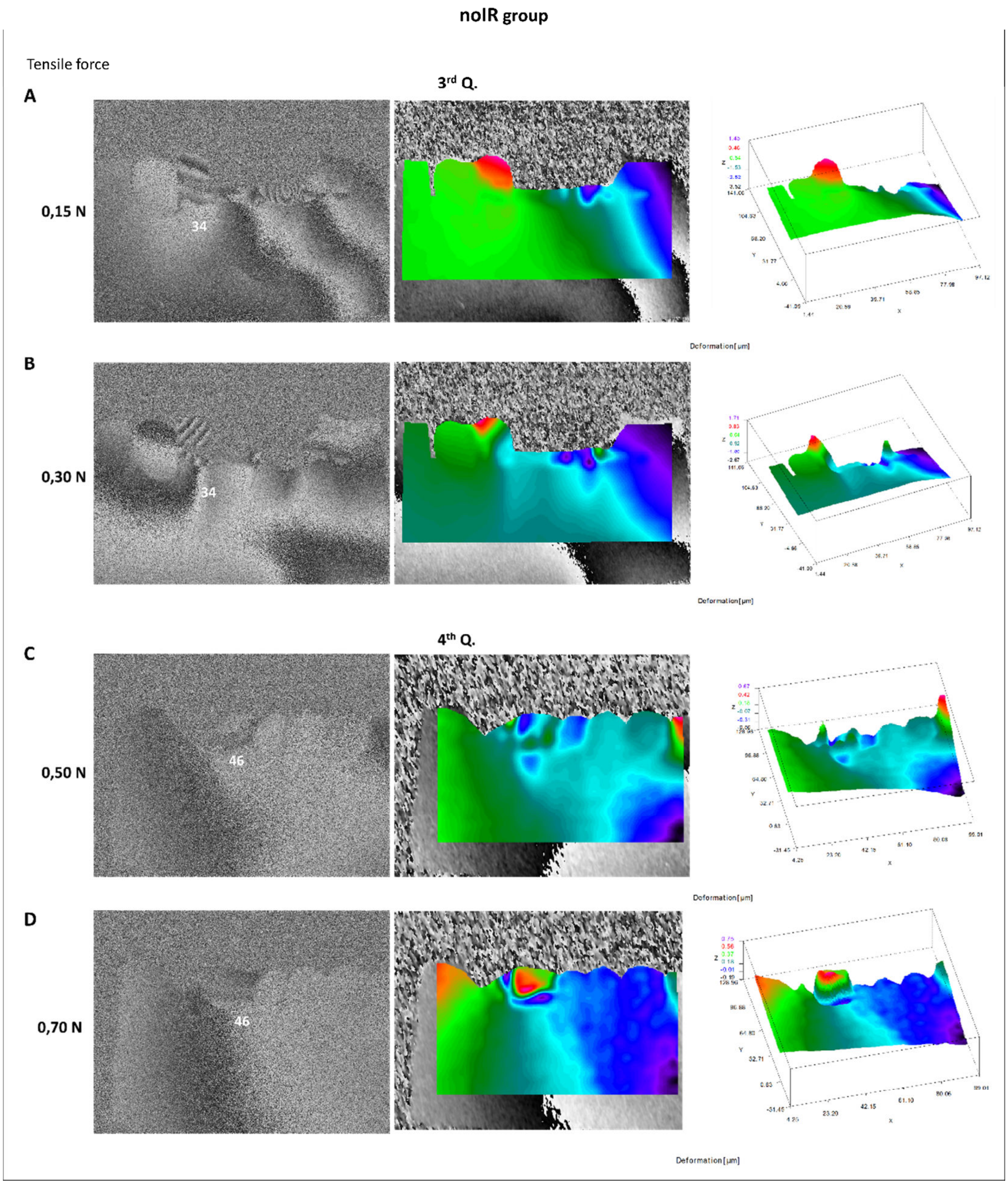

Fig. 4 - ESPI measurements for the group without indirect retention (noIR) upon application of a tensile force in the free-end saddle (out-of-plane displacement field). Raw fringe pattern, with tooth numbers depicted (left); filtered phase map image, color-coded (middle): red- highest displacement;blue- lowest displacement; graphical representation of the final 3D displacement values (right). **A** and **B**, Records for the third quadrant (3rd Q.). **C** and **D**, Records for the fourth quadrant (4th Q.).

CONCLUSIONS

Although conclusions drawn from *in vitro* models must be interpreted with caution, the results herein presented: i) reinforce the empirical consensus that indirect retainers promote cross-arch stress distribution; ii) suggest that forces transmitted to the tooth engaging the indirect retainer should not be neglected, but rather weighed during the framework construction; iii) demonstrate that the ability of indirect retention in preventing torque forces on direct abutment teeth depends on the magnitude of the dislodging force. According to the data here reported, beyond certain limits, intending to protect the abutment tooth from hazardous deformation with indirect retainers might be a misconception. The validation of these preliminary results via clinical and complementary experimental approaches warrant further investigation that will likely uncover the indirect retention relevance and effectiveness.

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