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Assessment of occlusal ridges in premolar teeth before and after dental treatment in equines

[*Avaliação das cristas oclusais de dentes pré-molares antes e após o tratamento dental em equinos*]

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ABSTRACT

Occlusal ridges of equines appeared in the evolutionary process of the species to increase its capacity of grazing and trituration. The difference in hardness of dental tissues (cementum, dentin, and enamel) and masticatory pressure on the occlusal surface of the hypsodont tooth promote the appearance of sharp occlusal ridges. The aim of this study was to measure and compare the height of the occlusal ridges (HOR) of the fourth premolar (Triadan 408) before and after odontoplasty. Ten *Mangalarga Marchador* mares aged 5 to 12 years, under extensive management, were evaluated by measuring the HOR in Triadan 408, using plaster models before, immediately after (D0), 15 days (D15) and 50 days (D50) after odontoplasty. Immediately after the procedure the HOR was only 21.9% of the HOR before the occlusal equilibration; however, in 15 days after odontoplasty, 65.9% of HOR was already reestablished and 80.3% after 50 days of the procedure. HOR in the buccal side resurfaced before the lingual HOR, suggesting a higher masticatory pressure of these buccal points. Results of the present study indicate that 15 days after the dental treatment, equines already have food trituration capacity, since HOR is apparent on the occlusal surface of the premolars that underwent odontoplasty.

Keywords: horse, dentistry, odontoplasty, teeth, occlusal equilibration

RESUMO

Cristas oclusais de equinos surgiram no processo evolutivo da espécie para aumentar sua capacidade de pastejo e trituração. A diferença na dureza dos tecidos dentários (cemento, dentina e esmalte) e a pressão mastigatória na superfície oclusal do dente hipsodonte promovem o aparecimento de cristas oclusais afiadas. O objetivo deste estudo foi medir e comparar a altura das cristas oclusais (HOR) do quarto pré-molar (Triadan 408) antes e após a odontoplastia. Dez éguas Mangalarga Marchador de cinco a 12 anos, sob manejo extensivo, foram avaliadas pela mensuração da HOR no Triadan 408, utilizando-se modelos de gesso antes, imediatamente após (D0), 15 dias (D15) e 50 dias (D50) após a odontoplastia. Imediatamente após o procedimento, a HOR era de apenas 21,9% da HOR antes do equilíbrio oclusal; entretanto, em 15 dias após a odontoplastia, 65,9% da HOR já estava restabelecida e 80,3% após 50 dias do procedimento. HOR na face vestibular ressurgiu antes da HOR lingual, sugerindo maior pressão mastigatória nestes pontos vestibulares. Os resultados do presente estudo indicam que 15 dias após o tratamento odontológico, os equinos já apresentam capacidade de trituração dos alimentos, uma vez que a HOR é aparente na superfície oclusal do pré-molar que foi submetido à odontoplastia.

Palavras-chave: cavalo, odontologia, odontoplastia, dente, equilíbrio oclusal

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INTRODUCTION

During equine species evolution process, which started 40 million years ago, molarization of premolars and the development of occlusal ridges with high crowned cheek teeth transformed the horse into a large hypsodont grazer. An important change occurred regarding the presence of enamel, dentin and cementum on the occlusal surfaces of hypsodont teeth, providing them the ability to graze for longer periods without significant loss of dental material (Mitchell *et al.,* 2003), together with a dental eruption in levels similar to the wear caused by pasture friction (Dixon and du Toit, 2010).

Mastication is a key factor affecting digestibility since it increases the proportion of food exposed to salivation and digestive processes (Hanley *et al.,* 1992) and the mouth is unique part of digestive tract where the food particle size can be reduced (Carmalt and Allen, 2008). Several parameters have been used to define dental efficiency in other species. For instance, molar occlusal surface area has been extensively used in humans, however, has not been measured in herbivore mammals (Gross *et al.*, 1995), in which enamel ridge length is more commonly studied (Lanyon and Sanson, 1986). The size of occlusal surface area also plays a role in masticatory efficiency because it is assumed to be directly related to the quantity of food being processed between the upper and lower dental arcades, increasing the number of food fragments cut or ground during mastication (Pérez-Barberia and Gordon, 1998).

Currently, the dental treatment endorsed for equines involves floating (rasping) to remove irregularities of the occlusal surface from incisors and cheek teeth, and it is called odontoplasty. Oral equilibration will be attained for the use of procedures that remove occlusal irregularities and should be performed at an appropriate frequency; otherwise, equilibration will never be reached due to the continuous eruption of teeth in the specie (Klugh, 2010a).

The present study aimed to assess height of ridge found on the occlusal surface of tooth Triadan 408 (lower right fourth premolar) in equines with malocclusion involving this tooth. These assessments were performed before and after occlusal equilibration treatment, using dental impression molds and plaster models.

MATERIAL AND METHODS

All procedures involving the use of animals received approval from the Ethics Committee on Animal Welfare (CEUA ULBRA) under the Protocol number 2019/564.

The study was carried out in 10 equines from the *Mangalarga Marchador* (*Equus ferus caballus*) breed horse farm located in Novo Hamburgo, Rio Grande do Sul State, Brazil. Equines were mares used as embryo donors, not pregnant, adults, between five and 12 years of age, with a mean weight of 433±26.50kg and a body condition score of 5, according to Henneke *et al.* (1983). Mares did not have any dental treatment performed for at least 18 months prior to the study and presented a similar dental abnormality score, with occlusal imbalance in premolars involving tooth Triadan 408, for example, wave or step malocclusion which underwent smoothing on the occlusal surface during the odontoplasty. They had been under extensive management for at least six months in native pasture and remained under this system during the study period.

The experimental procedure totaled 51 days. Teeth were identified with a modified Triadan numbering system and pulp numbering system according to du Toit et al. (2008). Oral disorders were standardized in the experimental horse group so that animals selected presented complete permanent dentition and moderate dental abnormalities, including excessive enamel points, hooks, ramps, degrees and wave involving Triadan 408. Exclusion criteria were only excessive enamel points, dental fracture, fistula, pulp expose, periodontal disease grade 3 and 4.

Molding was performed in different points in time as follows: the day before dental treatment (D0) molding 1 was performed (M1); immediately after dental treatment (D1) molding 2 was performed (M2); 15 days after dental treatment (D15) molding 3 was performed (M3); and 50 days after dental treatment (D50) molding 4 was performed (M4). Triadan 408 (lower right fourth premolar) was the tooth used for all measurements, following the study model with wild reindeers suggested by Pérez-Barbería and Gordon (1998).

Horses in this study were sedated with intravenous 0.02mg/kg detomidine (Detomidin®, Syntec, São Paulo, Brazil) and 0.01mg/kg supplementation was applied when needed, as described by Doherty and Schumacher (2010). A McPherson Oral Speculum was inserted and dental molds of quadrant 400 were made, including at least teeth 406-407-408-409.

Before molding oral cavity was washed to remove any food traces and it was dried out with a cotton towel. An impression tray was not used, and models were obtained by applying impression material manually. A light pressure was applied for five seconds to improve the reproduction of teeth occlusal surface (Fig. 1A). Molding technique was carried out as described by Neto *et al.* (2005).

Impression material was removed from the arcade when the setting time had been reached and a viscoelastic consistency was observed. For silicone removal, a slight traction was applied in parallel to the face axis, avoiding side movements. Models were considered acceptable (Fig. 1B) when no bubbles or cracks compromising its quality were observed, in accordance with guidelines published by Neto *et al.* (2005).

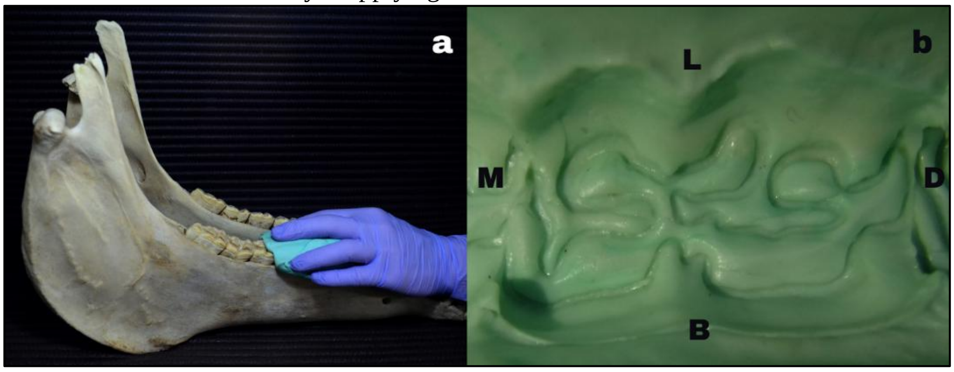

Figure 1. (a) Demonstration of manual application of impression material on equine mandibular bone at quadrant 400, involving teeth 406, 407, 408 fully and partially 409. (b) Model of molar 408 using impression material. L, lingual, M, mesial, B, buccal and D, distal.

Packaging was carried out immediately after molding. Models were made using stone plaster type III (Herodent®, Vigodent, Rio de Janeiro, Brazil) as describe by Capel [2017a] and following recommendations from Fernandes Neto *et al.* (2005) and Capel (2017b). Model removal from mold was performed by moves towards the teeth axis to avoid fractures and then the arcade reproduction was ready for ridge assessment and measurement.

Plaster models were visually assessed regarding the gross anatomy of Triadan 408 occlusal surface, focusing on the occlusal ridges of the tooth before and after dental treatment (D0, D1, D15 and D50). A digital Caliper (TMX®), with 0.01mm precision was used for measuring the height of occlusal ridge (HOR) with a depth rod.

Anatomical references described by Simpson (1951) were used for the measurement points on Triadan 408 tooth (Fig. 2). The author named occlusal infoldings on mandibular and maxillary cheek teeth that were used later in experiments on the occlusal angles conducted by Listmann *et al*. (2015).

Height of occlusal ridges (HOR) were measured on Triadan 408 at reference points: 1: entoconid, 2: metastylid, 4: protoconid, 5: ectoflexid, 6: hypoconid. The infolding defined as point 5 – metaconid – was excluded due to its proximity to point 6.

Points 1, 2 and 3 are located at the lingual side of the mandibular cheek teeth, while points 4, 5, and 6 are at the buccal side. These points were named: point 1: P1, point 2: P2, point 3: P3, point 4: P4, e point 6: P6.

Caliper's depth rod was placed at the deepest region of the infoldings (dentin depression) from the point measured. The instrument was inserted until it touched the enamel ridge of the point's infoldings, making a 90-degree angle between the depression and the ridge. The number obtained at the caliper's digital display was recorded as the point's HOR, as shown in Fig. 3.

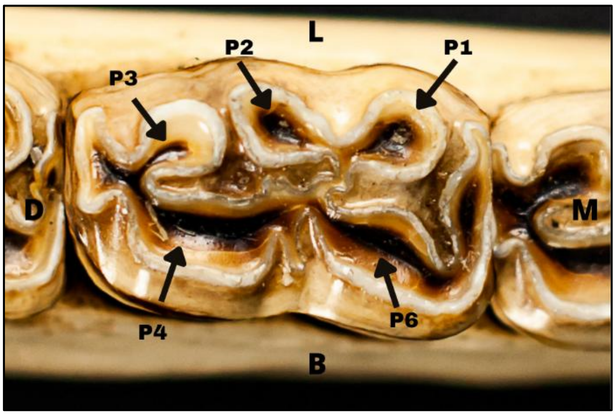

Figure 2. Occlusal surface of a mandibular cheek tooth showing points named: point 1: P1, point 2: P2, point 3: P3, point 4: P4, e point 6: P6. L, lingual, M, mesial, B, buccal and D, distal.

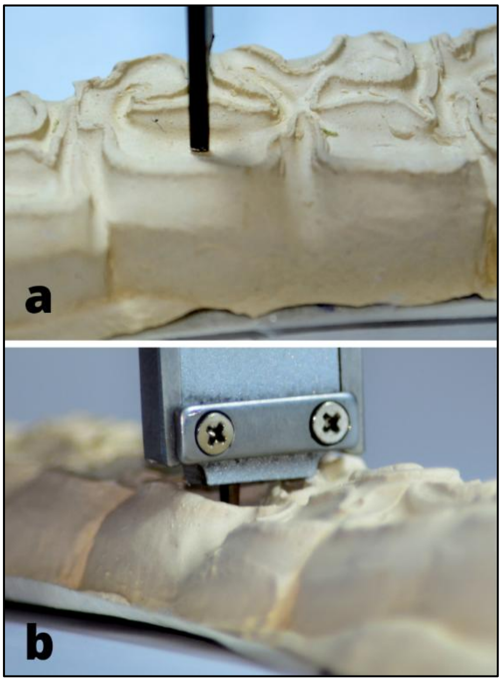

Figure 3. Use of Caliper to measure the height of occlusal ridge (HOR) of Triadan 408 in plaster models. (a). placement of Caliper's depth rod into the occlusal surface depression, at point 4. (b). HOR measurement at point 4, making a 90-degree angle between the depth rod and the equipment part touching the occlusal ridge.

Corrective odontoplasty was the type of dental procedure applied to animals, as described by Easley (2010) and Klugh (2010a), to smooth occlusal irregularities in premolars, molars and incisors, enamel points and favor rostrocaudal movement of the mandibular jaw. All dental and facial disorders observed were recorded in a dental chart, according to Galloway (2010).

Visual and manual external exam of the head was performed when the horse was sedated, and its mouth was washed. Next quantitative parameters were measured at the incisors to assist an appropriate occlusal equilibration: Occlusal center (OC), rostrocaudal movement (RCM), excursion to molar contact (EMC), diagonal incisor malocclusion (DGL) and temporomandibular joint (TMJ), as described by Allen (2008), Carmalt *et al*. (2006), Rucker (2002) and Pellachin (2014), respectively. DGL and TMJ parameters were performed using the equipment Maphorse 1, patented by Pellachin. After cheek teeth were floated, intermediary EMC was measured. After incisors correction, a final measurement of the following parameters was taken OC, RCM, EMC, DGL and TMJ.

Occlusal equilibration followed the order: Quadrants 100, 200, 300 and 400, incisors and premature contact checking without speculum.

All animals were weighted using a Rinnert® mechanical scale at days: D0, D15 and D50.

HOR measurements were performed at 5 points from each model (P1, P2, P3, P4 and P6), in each one of the experimental models: M1, M2, M3 and M4, at days D0, D1, D15 and D50, respectively. Two measurements from each point were taken and a value was generated by arithmetic mean.

HOR measurements from each point and from points total at different times were compared using ANOVA. The mean HOR difference between D0 and other times measures (D1, D15 and D50) were compared using Holm-Sidak multiple comparisons test. Results were analyzed using software Prism 7 (version 7.0a) for Mac OS X. A value of $p < 0.05$ was considered significant.

RESULTS

Starting and an ending aspect of corrective odontoplasty applied to animals is shown in Fig. 4.

Occlusal ridges underwent gross assessment by visual inspection of models from different moldings (M1, M2, M3 e M4) as shown in Fig. 5. On M1 the presence of ridges was observed all over the occlusal surface of Triadan 408. On M2, on the other hand, an important reduction of HOR was observed immediately after odontoplasty. However, those ridges were present in models M3 and M4.

All mean values of HOR measurements on tooth Triadan 408 obtained at times D0, D1, D15 and D50 were: 2.064mm±0.33; 0.452mm±0.42; 1.36mm±0.318; 1.657mm±0.318, respectively. These values revealed that immediately after the odontoplasty procedure, tooth Triadan 408 presented only 21.9% of initial HOR, however, 15 days after odontoplasty, 65.9% of HOR was restored and 80.3% in 50 days after the procedure. Mean HOR at D15 and D50 were higher than at D1 ($p<0.001$).

Means of HOR differences at different times after the procedure (D1, D15 and D50) presented significant difference in comparison to D0 (Fig. 6).

Although after 50 days of dental treatment HOR was still shorter than the day before the procedure (D0) ($p=0.028$), it is possible to observe a gradual increase of this height at the different times evaluated. There was an escalating resurge process of occlusal ridges between days 15 and 50.

The mean of HOR difference from each point (P1, P2, P3, P4 and 6) was compared at the different times (D0 to D1, D0 to D15 and D0 to D50) and the difference was significant ($p<0.0001$) in most of the points and times assessed. However, at P3 the mean HOR difference when comparing D0 to D15 and D0 to D50 was not statistically significant ($p=0.2591$), as well as at P4 when comparing D0 to D50 ($p=0.2956$).

In a comparative analysis of the mean value of a point compared to another, within the same period (D0, D1, D15 or D50), significant differences were found at D15 and D50 when the comparison involved P4 and P6, but not when compared to P3. When comparing the mean value at day 15 to day 50, the percentage increase in HOR for each point was: 21% at point 1; 24.5% at point 2; 2% at point 3; 34.3% at point 4 and 28.3% at point 6.

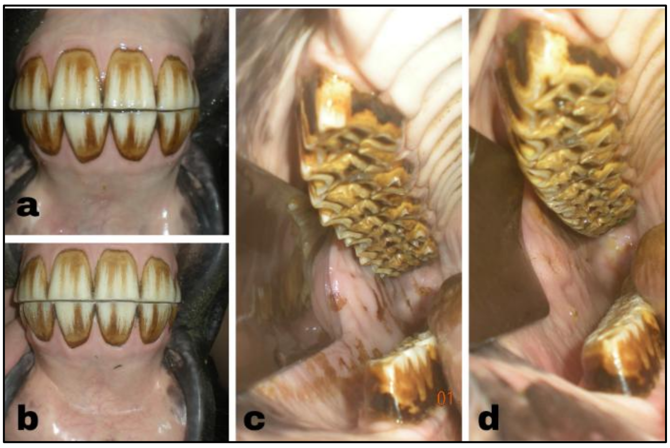

Figure 4. Photographs of before and after dental treatment. (a). Incisors before odontoplasty, (b). Incisors after odontoplasty, (c). Quadrants 100 and 400 before dental treatment, (d). Quadrants 100 and 400 after dental treatment.

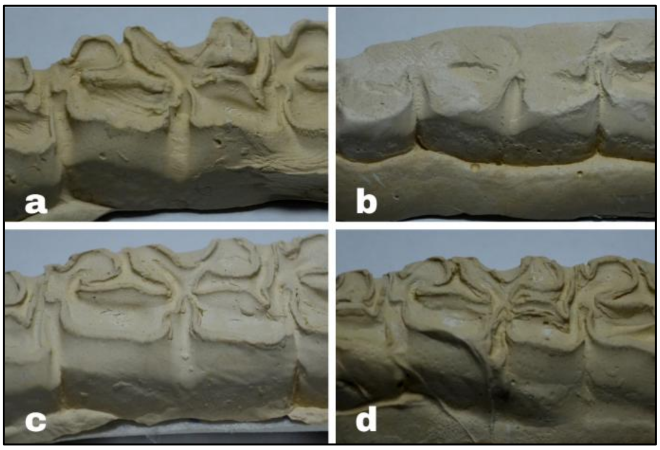

Figure 5. Plaster models of Triadan 408 occlusal surface. a) model 1 from day 0 (before dental treatment); b) model 2 from day 0 (immediately after dental treatment); c) model 3 from day 15 (15 days after dental treatment); and d) model 4 from day 50 (50 days after dental treatment).

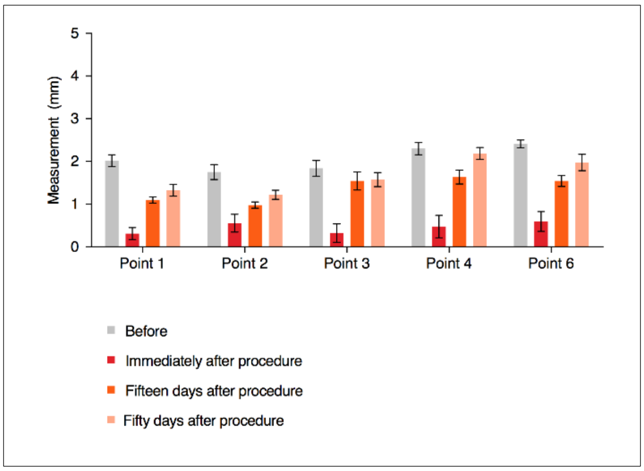

Figure 6. Comparison of mean of HOR difference at different times (D0 to D1, D0 to D15 and D0 to D50). $p<0.05$.

DISCUSSION

From gross observations of models and HOR measurements, it was evident that odontoplasty procedures smoothed considerably the occlusal surface of the tooth affected by the dental disorder, almost completely wearing down the height of occlusal ridges on Triadan 408 tooth, being measured only 21.9% of HOR immediately after odontoplasty. However, the effects of the treatment in occlusal surface do not last too long since in 15 days those ridges are already clinically apparent. After 50 days of treatment, occlusal ridges remain apparent, with no evident gross anatomical differences in relation to 15 days after treatment.

Although significant values have been observed in a comparison between the mean HOR differences from each point, a decreasing numerical value was evident when we compared HOR between days D0 and D15 and D0 and D50. This was observed in nearly all measurements, except at anatomical reference point 3, thus, allowing us to suggest that at days 15 and 50 after odontoplasty, HOR is in fact resurging. These results support the hypothesis that HOR builds back first at the points located on the occlusal buccal side of the mandibular check teeth (P4 e P6) due to the higher pressure applied during the impact and attrition phase at the end of the lateral mandibular excursion, as described by Mitchell (2003). Besides that, dentin depressions on P4 and P6 on this occlusal side are wider when compared to P1, P2 and P3, and it supposedly contributes to a faster deepening of those points (P4 and P6), since the study hypothesis is that occlusal ridges resurge due to the wear of tissues with lower hardness (dentin and peripheral cementum) surrounding the enamel and allow it to remain unchanged and apparent, in the form of sharp ridges. Those results are in accordance with observations made by Boyde (1997), which define those occlusal ridges of cheek teeth arise due to the differences in hardness of the elements compounding the teeth.

Point 3 presented values different from expected and dissonant from the other points in the comparison of the difference mean of HOR from each point in different times, as well as the mean value of a point in comparison to another, in the same period. This can have occurred due to a measurement error, since it has a smaller dentin depression, making it more difficult to place the caliper's depth rod correctly. Its morphology can be a factor to be taken into consideration to justify the results found, however further studies are needed to elucidate the question.

At point 4, comparison of D0 to D50 presented a non-significant difference mean of HOR and this can be due to a faster resurge of the occlusal ridge at this point, thus its HOR at day 50 was like the HOR at day 0, showing a statistically non-significant result ($p=0.2956$).

The possibility of occlusal ridge resurging being associated with a quick dental eruption should not be considered as an explanation to our results since the dental eruption compensation to occlusal wear has been estimated at 2 to 4 mm/year at a maximum rate of 9 mm in young equine (Dixon e du Toit, 2010; Klugh, 2010b; Listmann, 2015). Besides that, Klugh (2010a)) reports that dental eruption is reduced when occlusal equilibration is performed because there is better distribution of forces of mastication on cheek teeth. In the present study, after 15 days only, occlusal ridge already presented a difference in the mean value when compared to the HOR before dental treatment of 0.70 mm. Thus, there is no evidence supporting the hypothesis of a higher eruption rate after odontoplasty procedures that, in its turn, aimed at distributing mastication pressure on cheek teeth, hence, contributing to the slowdown of eruption rate so that teeth will last longer.

The animals used in the experiment have been held in extensive management and it may have influenced the resurgence of occlusal ridges 15 days after the odontoplasty procedure, reinforcing the hypothesis that food attrition on the occlusal surface has promoted the wear of cementum and dentin, favoring the exposure of a thin layer of sharp enamel. Feeding animals with hay or allow extensive management soon after odontoplasty seems to foster the resurgence of occlusal ridges.

In the present study there was no statistically significant difference in body condition score ($p>0.05$) in different measurement times after the dental treatment, agreeing to results reported by Pagliosa *et al.* (2006) and Carmalt *et al*. (2004) that performed similar studies.

Measurement of occlusal surface concurrently with digestibility assessments and particle size in feces are indicators of chewing effectiveness that contribute to more conclusive results on the influence of dental treatment over diet nutrient digestion on the equine specie, considering that Carmalt and Allen (2008) reported that particles in the stomach contents were the same size as particles in contents from the small colon or rectum, indicating that mastication is the sole responsible for physical breakdown of the ingested feed.

Johnson *et al.* (2017) recently carried out a study evaluating the fecal fiber length (FFL) in 20 adult donkeys before and after dental treatment. The authors observed significant reductions in mean FFL after dental treatment, possibly characterizing an improved attrition efficiency that occurs after corrective dental smoothing and can generate a fecal particle size reduction. Filippo *et al.* (2018) reported similar results; however, the study was conducted with 30 equines of different breeds with mild to moderate dental abnormalities and they also observed a significant fiber length reduction after dental treatment. Studies evaluating FFL together with the present study assessing HOR suggest that chewing effectiveness after dental treatment is not affected and can justify results obtained in previous studies carried out by Pagliosa *et al.* (2006), Zwirglmaier *et al. (*2013) and Moraes *et al.* (2019) that revealed an improvement in some digestibility parameters after occlusal adjustment. Studies involving particle size in feces and HOR can provide important data about feed digestion in the equine specie.

There isn´t much research on this subject, conclusions about the ideal HOR after dental treatment are limited. The aim of odontoplasty is the correction of arcades imbalance and occlusal irregularities, thus ideal and functional HOR after dental treatment may be lower than previously found in a condition of occlusal imbalance.

CONCLUSION

After 50 days of dental treatment involving occlusal wear of Triadan 408, it was possible to observe a gradual increase of this height occlusal ridges of this tooth, leading to the conclusion that occlusal ridges were in an escalating resurge process between days 15 and 50. At least enamel occlusal ridges of that tooth were emerging on occlusal surfaces short after (15 days) odontoplasty procedures in animals under extensive management.

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