RESEARCH ARTICLE

The Oropharyngeal Seal, the Primary Mechanism Involved in Maintaining the Soft Palate in a Ventral Position Within the Nasopharynx of Equids: Its Role in Maintaining a Horse's Health and Well-Being, along with Surgical Approaches that Could Potentially Enhance Its Function.

Tom Ahern

Abstract

The notion of an oral seal mechanism arose in an attempt to explain the rationale behind a newly developed surgical procedure, an oral palatopharyngoplasty. This theory was further refined and described after viewing numerous treadmill recordings. Eventually, its role in maintaining a patent nasopharyngeal airway was established, and the term palatal instability was introduced. A critical review of the role or efficacy of surgical procedures, many of which were not originally designed to treat this condition, was needed. Likewise, the interrelationship between this mechanical dysfunction and other airway issues within the larynx and nasopharynx, along with the health of the lower airways in general, and a possible role in maintaining airway patency during paradoxical sleep, were in urgent need of investigation.

Keywords: Horse, palatal instability, oropharynx, seal, soft palate.

Ind J Vet Sci and Biotech (2025): 10.48165/ijvsbt.21.2.31

INTRODUCTION

In the equid, the soft palate forms a structural barrier between the digestive and respiratory tracts during locomotion. This is necessary to enable the animal, which may be grazing at the time, to flee its predator without the contents of the buccal cavity being drawn into its airway. Traditionally, contact between the caudal free border of the soft palate and the base of the epiglottis at the intrapharyngeal ostium was seen as the primary mechanism that maintained the palate in a ventral position within the nasopharynx. However, in 1999, it was proposed that this was, in fact, a secondary mechanism, while an oral seal created between the base of the tongue and the ventral surface of the soft palate was the primary one [Ahern 1999]. This explained why in a 1997 study, blocking the innervation to the hyoepiglottic muscle, which resulted in a retroverted epiglottis, did not lead to dorsal displacement of the soft palate (DDSP) [Derksen et al. 1997].

This seal was referred to as the oropharyngeal seal (OPS) [Ahern 1999]. It was created during deglutition, with air being evacuated from the oropharynx, and was then maintained with tension and closure of a rostral valve at the isthmus faucium and a caudal valve at the intrapharyngeal ostium [Ahern 1999]. The consequences of a breakdown in this seal had also been described [Ahern 1999]. In 2006, a description of this mechanism was again published [Lane et al. 2006]; however, this lacked any reference to the original 1999 publication. A lengthy study was proposed into these theories, and this was carried out by researchers at the University of Bristol [Allen, Franklin 2013a]. Rather than simply refer to this occurrence as a breakdown of the OPS mechanism, they introduced the term palatal instability (PI) [Allen, Franklin 2013a]. This work confirmed the potential for this condition to negatively affect racing performance [Allen, Franklin 2013b].

Endoscopic presentation of the OPS

A view of the caudal nasopharynx with the OPS in place shows the palate being drawn into the piriform recesses on either side of the epiglottis and a space present between the ventral surface of the epiglottis and the dorsal soft palate [Ahern 1999] (figure 1). When the seal is broken at the isthmus faucium, air enters the oropharynx, the caudal palate flattens, and at the same time rises,

Knockdown Lodge, 17 Keymer Street, Ascot, 6104, Western Australia

Corresponding Author: Tom Ahern, Knockdown Lodge, 17 Keymer Street, Ascot, 6104, Western Australia

How to cite this article: S Ahern, T. (Year). The oropharyngeal seal, the primary mechanism involved in maintaining the soft palate in a ventral position within the nasopharynx of equids: Its role in maintaining a horse's health and well-being, along with surgical approaches that could potentially enhance its function. Ind J Vet Sci & Biotech, 21(2), 136-141

Source of support: Nil

Conflict of interest: None

making broader contact with the epiglottis (figure 2). The subepiglottic space is no longer evident [Ahern 1999]. Once the OPS is disrupted, the severity of the resultant PI is determined with reference to the extent to which the rima glottis is obscured [Allen, Franklin 2013b].

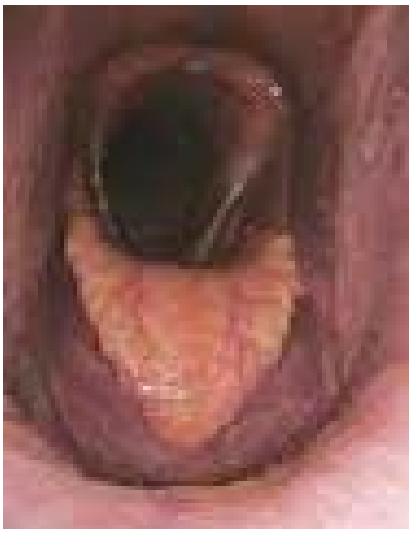

Figure 1 - The caudal soft palate being drawn into the piriform recesses with a space beneath the epiglottis evident. Air has been vacated from the oropharynx, and the oropharyngeal seal is patent.

Figure 2 - The caudal soft palate is flattened with the epiglottis in full contact. Air has entered the oropharynx, and the oropharyngeal seal has been broken.

Unusual Presentations of the OPS

The caudal free border of the soft palate is normally subepiglottic when the OPS is patent. However, this seal can on occasion be formed with the epiglottis beneath the palate. Diagram 3 shows a displaced palate with ulceration of the mid free border, while in Diagram 4, the same palate has formed an OPS with what was later found to be an entrapped epiglottis beneath it. It may be that the entrapping tissues had partially obliterated the subepiglottic space, making it difficult for the palate to be maintained in this position. Diagram 5 is a view taken during overground endoscopy. Here, while the palate is displaced, it is also being drawn into the piriform recesses to create an OPS.

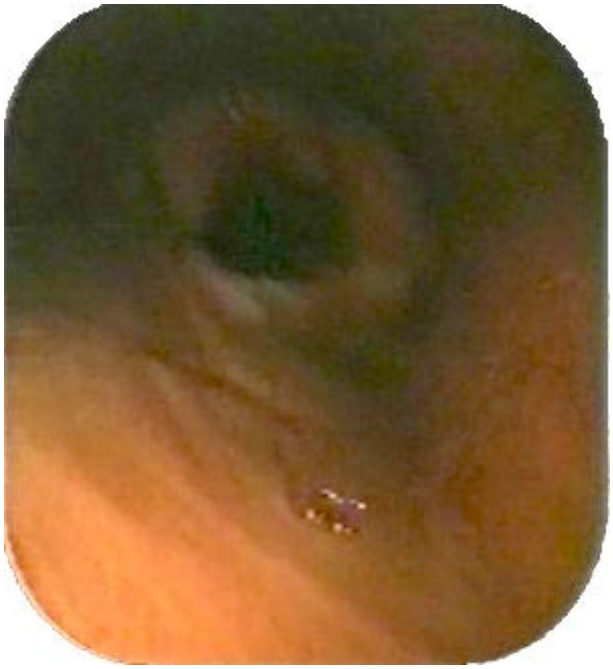

Figure 3 - A soft palate displaced above the epiglottis. Note mid free border ulceration.

Figure 4 - The same soft palate forming an oropharyngeal seal over an entrapped epiglottis.

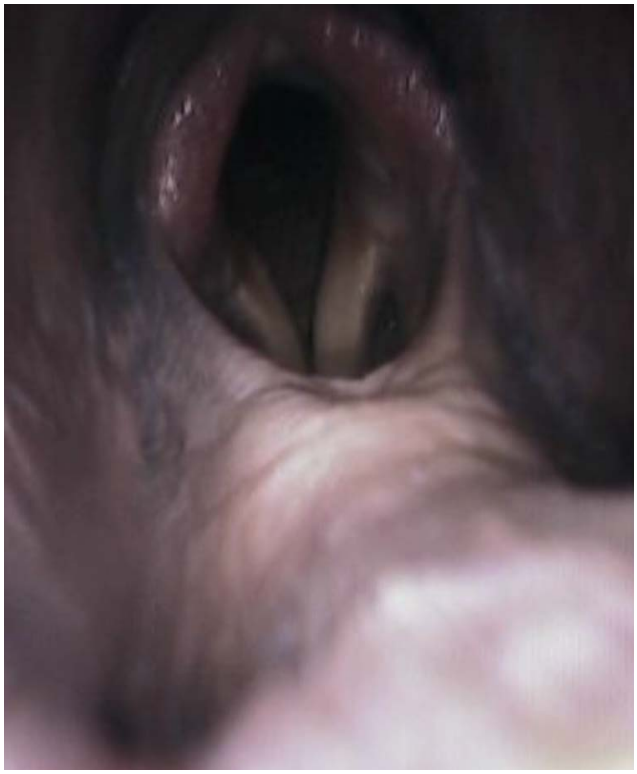

Figure 5 - A dorsally displaced soft palate with the caudolateral free border being drawn into the piriform recesses to form an oropharyngeal seal while exercising.

Physical and Medical Changes Associated with OPS Disruption or PI

Alterations to airflow, which could contribute to poor respiratory performance, had been demonstrated [Allen, Franklin 2013b]. An association between PI and axial deviation of the aryepiglottic folds (ADAF) had been suggested but not yet investigated [Lane et al 2006: Kannegieter, Dore 1995]. The postulated consequences of contamination of the airways with orally derived material during periods of PI or DDSP had also been postulated but had not been formally investigated [Ahern 1999: Ahern 1993a], although some associations had been observed [Van Erck 2011]. The role of the OPS in maintaining the airway during paradoxical sleep had also not been considered, despite indications of an association between sleep deprivation and PI [Ahern 2018a: Ahern 2018b]. Indeed, an antiquated notion that "horses would never choose to and, in fact, were unable to take air orally" was in urgent need of review [Ahern 2021: Ahern 2019].

Surgical Approaches to Reduce or Eliminate Palatal Instability (PI) with or without Resultant Dorsal Displacement of the Soft Palate (DDSP)

There have been numerous surgical procedures developed that attempt to reduce or eliminate inappropriate DDSP during exercise. Success was usually claimed when episodes of DDSP were either significantly reduced or no longer occurred.

Since the discovery of the OPS with associated PI, and given that in most instances DDSP is preceded by PI [Lane et al: Allen, Franklin 2013a], surgical success should now include a reduction or elimination of episodes of PI as well as DDSP.

Staphylectomy: A procedure based on the same premise as the uvulopalatopharyngoplasty [Sanders et al 1988], a surgical approach used to treat snoring and sleep apnea. Based on a perceived elongation of the soft palate, the staphylectomy procedure [Heffron, Baker 1979: Anderson et al 1995] also looked to address this. However, if too much tissue was resected, it could also potentially destabilize the seal at the isthmus faucium, which is the caudal valve of the OPS. This seemed at odds with the current understanding of pharyngeal function in the horse. Certainly, post-resection, if a horse did elect to obtain some air via the oral route, then its passage past the caudal valve would meet with less resistance. Some treadmill studies showed these horses galloping, palates fully displaced, abnormal noise absent, all apparently due to a reduction in resistance with the lesser amount of obstructing tissues. However, and not uncommonly, these horses would later present with significant performance-limiting lower airway infections, most probably attributable to contamination with oral feed material, bacteria, and saliva [Ahern 1999: Ahern 1993].

Myotomy or Myectomy of the Laryngeal Retractor Muscles: It had been postulated that contraction of these muscles, which caused the larynx to move caudally, could potentially disrupt the seal at the intrapharyngeal ostium [Cook 1981]. The epiglottis would be drawn with the larynx away from the free border of the soft palate, which could increase the potential for DDSP to occur [Cook 1981]. By transacting or removing a portion of these muscles [Llewellin, Petrowitz 1997: Harrison, Raker 1988], the horse was subsequently less able to draw the larynx caudally. However, the sequence of events that are postulated to disrupt the OPS [Ahern 1999] begins with relaxation of the rostral valve at the isthmus faucium, allowing air to enter the oropharynx, which can then secondarily facilitate a breakdown at the intrapharyngeal ostium (caudal valve). Therefore, these procedures may well reduce the instances of DDSP that follow PI but are unlikely to prevent PI itself from occurring.

Laser Palatoplasty: The purpose of this procedure [Hogan, Palmer 2002: Smith, Emberson 2003], which was to cause scar tissue contraction at the free border of the soft palate to tighten the caudal seal of the OPS, was sound. Histologic studies, however, failed to support the concept of stiffening, as induration of intrinsic musculature appeared to counter any contraction secondary to scar tissue formation [Alkabes et al 2010]. Again, this procedure addresses the caudal valve of the OPS but not the rostral valve and, hence, is unlikely to reduce OPS disruption.

Laryngeal Tie Forward (LTF): The theory behind the LTF procedure [Woodie et al 2005] was based on the

consequence of the larynx being maintained in a caudal position. This situation was achieved experimentally by resecting the thyrohyoideus muscles [Ducharme et al 2003], which were responsible for drawing the larynx rostrally. Seven of ten horses then experienced DDSP, of which five of six did not after an LTF procedure [Ducharme et al 2003]. A theory that mirrored that behind the development of the retractor muscle myotomy and myectomy procedures. While a myectomy permitted the larynx to move rostrally in a more unencumbered manner, the LTF actively drew the larynx forward to a position where it would be maintained permanently. A potential downside to the procedure was that as the larynx was drawn rostrally, it also moved dorsally, narrowing the nasopharynx. A study revealed a 14-17% reduction in nasopharyngeal vertical diameter at or about the level of the tip of the epiglottis following LTF in 25 horses [Offord et al 2015]. This study was, however, performed in standing/static animals. Under race conditions, tension in the laryngeal retractor muscles would, to a large extent, counter this effect and draw the larynx, and with it the hyoid apparatus, both caudally and ventrally. This may explain why, anecdotally, the procedure had been widely adopted in the standardbred industry but less so in thoroughbred racing. Drivers or riders in both pacing and trotting codes rarely release rein pressure, so the horse is said to be constantly "on the bit." The horses' "lean" on the bit triggers a response or tension in the laryngeal retractor muscles [Holcombe, Ducharme 1999]. Jockeys in thoroughbred racing are more likely to have a horse "off the bit" and therefore less likely to trigger this reflex contractile effect. In particular, with the onset or approach of fatigue, when the horse's musculature is beginning to relax, it is more likely that the larynx will ride forward and cause some reduction in pharyngeal airway. As with retractor muscle procedures, the LTF would enhance contact between the free border of the soft palate and the base of the epiglottis or caudal valve of the OPS. However, as with myotomies, the LTF procedure does not directly address episodes of rostral valve breakdown, and hence, as much as DDSP is addressed, PI is not. Because of this, UK surgeons often performed thermal cautery [Offord et al 2015] on the soft palate in conjunction with an LTF.

Palatal Scleropathy: One of several approaches looking to stiffen or tense the soft palate in an attempt to reduce dorsal billowing and potentially tighten the seal at the isthmus faucium. Sodium tetradecyl sulfate was more commonly injected via the nasal route. Useful performance improvements have been reported [Marcoux et al 2008: Jean et al 2011]. However, a histological study following low-dose scleropathy failed to demonstrate any significant increase in palatal tension, although this may have been dose dependent [Munoz et al 2010].

Soft Palate Thermal Cautery: Cauterisation of the mid and rostral surface of the soft palate [Ordidge 2001]. Scar tissue formation certainly resulted in many cases in a measurable reduction in the circumference at the isthmus. Anecdotally, it has been referred to as giving shorter rather than longer-term improved performance. Best results were often seen in the weeks immediately following treatments. There have been suggestions that the degree of tension in the palate during this period is contributed to by the post-treatment inflammation itself. As the inflammation subsides, this tension may also decline. Reports on success rates were mixed [Barakzai 2015: Reardon et al 2008].

Oral Palatopharyngoplasty OPP or Tension Palatoplasty TPP: As much as these procedures were developed prior to the term palatal instability entering the literature, the concept of some form of oral seal had always been considered [Ahern 1999]. The primary aim of the procedure is to tense the tissues that directly abut the broad tendon or aponeurosis of the soft palate [Ahern 1992: Ahern 2018]. The surgery does not, as is the case with thermal cautery or scleropathy, cause any injury to the caudal segment of the palate. Flaccidity permitting ventral movement of the palate in this region is paramount if the palate is to be able to conform with the ventral surface of the oropharynx. This includes the mucosa of the piriform recesses, which permit the OPS to be formed. There have been only two reports on its usefulness, and these were contradictory [Ahern 1993: Reardon et al 2007]. The author of the latter did, however, state [per comm 2010] that the surgeon in this study had reported that the majority of his surgeries had experienced a degree of dehiscence. As initially stated, a guarded prognosis accompanied wound dehiscence [Ahern 1992].

DISCUSSION

A horse employs flight as its main form of defense. For this reason, a unique anatomical and functional arrangement has developed between the oro- and nasopharynx to permit the horse to flee without the contents of the buccal cavity (feed, saliva, and oral commensal bacteria) being drawn into the airway. As well as palato-epiglottal contact, a functional seal between the tongue and soft palate works to maintain the integrity of the pharyngeal airway.

We now understand that it is not just DDSP that can have a negative effect on performance parameters, as PI also contributes to these. It, however, remains that athletic performance appears to be the only consequence that we are prepared to consider and thus research in relation to PI and DDSP in horses.

Interestingly, in human medicine, upper airway issues, including similar forms of pharyngeal dysfunction, have been shown to impact sleep, lower airway health, digestive parameters, and ultimately cardiac health.

It may be time for veterinary science to broaden its horizons.

REFERENCES

Ahern, T. J. (1999). Pharyngeal dysfunction during exercise, including disruption of the oropharyngeal seal (OPS) and

dorsal displacement of the soft palate (DDSP). *J. Equine Sci.*, *19*(4), 226–231. https://doi.org/10.1016/s0737-0806(99)80309-8

Derksen, F. J., Holcombe, S. J., & Stick, J. A. (1997). Applied physiology of the upper airway. In N. W. Ranted & M. L. Hauser (Eds.), *Proceedings: Dubai International Equine Symposium* (pp. 23–35).

Lane, J. G., Bladon, B., Little, D. M., Naylor, J. R., & Franklin, S. H. (2006). Dynamic obstructions of the equine upper respiratory tract. Part 1: Observations during high-speed treadmill endoscopy of 600 Thoroughbred racehorses. *Equine Vet. J.*, *38*(5), 393–399. https://doi.org/10.2746/042516406778400583

Allen, K. I., & Franklin, S. (2013). Characteristics of palatal instability in Thoroughbred racehorses and their association with the development of dorsal displacement of the soft palate. *Equine Vet. J.*, *45*(4), 454–459. https://doi.org/10.1111/evj.12004

Allen, K., & Franklin, S. (2013). The effect of palatal dysfunction on measures of ventilation and gas exchange in Thoroughbred racehorses during high-intensity exercise. *Equine Vet. J.*, *45*(3), 350–354. https://doi.org/10.1111/j.2042-3306.2012.00627.x

Kannegieter, N. J., & Dore, M. L. (1995). Endoscopy of the upper respiratory tract during treadmill exercise: A clinical study of 100 horses. *Aust. Vet. J.*, *72*(3), 101–107. https://doi.org/10.1111/j.1751-0813.1995.tb15020.x

Ahern, T. J. (1993a). Acquired pharyngeal dysfunction (APD). *J. Equine Vet. Sci.*, *13*(3), 125–128. https://doi.org/10.1016/S0737-0806(07)80056-6

Van Erck, E. (2011). Dynamic respiratory videoendoscopy in ridden sport horses: Effect of head flexion, riding, and airway inflammation in 129 cases. *Equine Vet. J.*, *43*(40), 18–24. https://doi.org/10.1111/j.2042-3306.2011.00492.x

Ahern, T. (2018). Behavioural changes in a ten-year-old gelding that presented with palatal instability, and observations made following an oral palatopharyngoplasty. *World J. Vet. Sci.*, *6*, 38–41. http://dx.doi.org/10.12970/2310-0796.2018.06.08

Ahern, T. (2018). Sleep attacks with associated sleep terrors in a six-year-old Thoroughbred gelding. *World J. Vet. Sci.*, *6*, 19–22. http://dx.doi.org/10.12970/2310-0796.2018.06.03

Ahern, T. (2021). Horses are obligate nasal breathers: But does this obligation still apply when a horse's 'nasopharyngeal air supply' and with this its 'defense through flight', is compromised? *World J. Vet. Sci.*, *9*, 27–30. https://doi.org/10.12970/2310-0796.2021.09.05

Ahern, T. (2019). Mouth opening during ridden exercise in sports horses: An evasive behaviour, an indication of pain or discomfort, or a physical adjustment to facilitate the oral passage of air during inspiratory efforts. *World J. Vet. Sci.*, *7*, 10–13. https://doi.org/10.12970/2310-0796.2019.07.03

Sanders, M. H., Johnson, J. T., Keller, F. A., & Seger, L. (1988). The acute effects of uvulopalatopharyngoplasty on breathing during sleep in sleep apnea patients. *Sleep*, *11*(1), 75–89. https://doi.org/10.1093/sleep/11.1.75

Heffron, C. J., & Baker, G. J. (1979). Observations on the mechanism of functional obstruction of the nasopharyngeal airways in the horse. *Equine Vet. J.*, *11*, 142–147. https://doi.org/10.1111/j.2042-3306.1979.tb01326.x

Anderson, J. D., Tulleners, E. P., Johnston, J. K., & Reeves, M. J. (1995). Sternothyrohyoideus myectomy or staphylectomy for treatment of intermittent dorsal displacement of the soft palate in racehorses: 209 cases (1986-1991). *J. Am. Vet. Med. Assoc.*, *206*(12), 1909–1912. https://doi.org/10.2460/javma.1995.206.12.1909

Cook, W. R. (1981). Some observations on form and function of the equine upper airway in health and disease: I. The pharynx. *Proc. Am. Assoc. Equine Pract.*, *27*, 355–391.

Llewellyn, B., & Petrowitz. (1997). Sternothyroideus myotomy for the treatment of dorsal displacement of the soft palate. In *Proceedings: Annual Convention AAEP* (pp. 239–243).

Harrison, I. W., & Raker, C. W. (1988). Sternothyrohyoideus myectomy in horses: 17 cases (1984–1985). *J. Am. Vet. Med. Assoc.*, *193*(10), 1299–1302. https://doi.org/10.2460/javma.1988.193.10.1299

Hogan, P. M., & Palmer, S. E. (2002). Transendoscopic laser cauterization of the soft palate as an adjunctive treatment for dorsal displacement in the racehorse. In *Proceedings of the 48th Annual American Association of Equine Practitioners Convention* (pp. 228–230).

Smith, J. J., & Embertson, R. M. (2003). Sternothyroideus myotomy, staphylectomy, and soft palate thermoplasty for treatment of dorsal displacement: 102 Thoroughbred racehorses. In *Proceedings of the 49th Annual American Association of Equine Practitioners Convention* (pp. 377–380).

Alkabes, K. C., Hawkins, J. F., Miller, M. A., Nauman, E., Widmer, W., Dunco, D., Kras, J., Couetil, L., Lescun, T., & Gautam, R. (2010). Evaluation of the effects of transendoscopic diode laser palatoplasty on clinical, histologic, magnetic resonance imaging, and biomechanical findings in horses. *Am. J. Vet. Res.*, *71*(5), 575–582. https://doi.org/10.2460/ajvr.71.5.575

Woodie, J., Ducharme, N., Kanter, P., Hackett, R., & Erb, H. (2005). Surgical advancement of the larynx (laryngeal tie-forward) as a treatment for dorsal displacement of the soft palate in horses: A prospective study 2001–2004. *Equine Vet. J.*, *37*(5), 418–423. https://doi.org/10.2746/042516405774480076

Ducharme, N. G., Hackett, R. P., Woodie, J. B., Dykes, N., Erb, H. N., Mitchell, L. M., & Soderholm, L. V. (2003). Investigations into the role of the thyrohyoid muscles in the pathogenesis of dorsal displacement of the soft palate in horses. *Equine Vet. J.*, *35*, 258–263. https://doi.org/10.2746/042516403776148200

Offord, S., Tulloch, L. K., Franklin, S. H., Tremaine, W. H., Woodford, N. S., & Allen, K. J. (2015). The effect of the laryngeal tie-forward procedure and soft palate cautery on nasopharyngeal diameter in horses. *Vet. Rec.*, *176*(1), 19. https://doi.org/10.1136/vr.102509

Holcombe, S. J., & Ducharme, N. G. (1999). Pharynx. In J. A. Auer & J. A. Stick (Eds.), *Equine Surgery* (pp. 337–348). W.B. Saunders Co.

Marcoux, M., Picandet, V., Celeste, C., Macieira, S., Morisset, S., Rossier, Y., Schambourg, M., & Jean, D. (2008). Palatal sclerotherapy: A potentially useful treatment of intermittent dorsal displacement of the soft palate in juvenile Standardbred racehorses. *Can. Vet. J.*, *49*(6), 587–591. PMCID: PMC2387264 PMID: 18624069

Jean, D., Picandet, V., Celeste, C., Macieira, S., Cesarini, C., Morisset, S., Rossier, Y., & Marcoux, M. (2011). Palatal sclerotherapy for the treatment of intermittent dorsal displacement of the soft palate in 51 Standardbred racehorses. *Can. Vet. J.*, *52*(11), 1203–1208. PMID: 22547840 PMCID: PMC3196012

Munoz, J. A., Arcoux, M., Picandet, V., Theoret, C. L., Perron, M. F., & Lepage, O. M. (2010). Histological and biomechanical effects of palatal sclerotherapy in the horse using sodium tetradecyl sulfate. *Vet. J.*, *183*(3), 316–321. https://doi.org/10.1016/j.tvjl.2008.11.006

Ordridge, R. M. (2001). The treatment of dorsal displacement of the soft palate by thermal cautery: A review of 252 cases. *World Equine Airway Symposium*, 2.

Barakzai, S. Z. (2015). Is there a place for thermocautery of the soft palate? *Equine Vet. Educ.*, *27*(7), 387–388. https://doi.org/10.1111/eve.12337

Reardon, R. J. M., Fraser, B. S. L., Heller, J., et al. (2008). The use of race winnings, ratings and a performance index to assess the effect of thermocautery of the soft palate for treatment of horses with suspected intermittent dorsal displacement: A case-control study in 110 racing Thoroughbreds. *Equine Vet. J.*, *40*, 508–513.

Ahern, T. J. (1992). Oral palatopharyngoplasty. *J. Equine Vet. Sci.*, *13*(4), 185–188. https://doi.org/10.1016/S0737-0806(06)81000-2

Ahern, T. (2018). The modified oral palatopharyngoplasty or modified Ahern procedure. *World J. Vet. Sci.*, *6*, 33–37. http://dx.doi.org/10.12970/2310-0796.2018.06.07

Ahern, T. J. (1993b). Oral palatopharyngoplasty: A survey of one hundred post-operative raced horses. *J. Equine Vet. Sci.*, *13*(12), 670–672. https://doi.org/10.1016/S0737-0806(06)81554-6

Reardon, R., Bladon, B. M., & Lane, J. G. (2007). Oral palatopharyngoplasty for treatment of horses with signs associated with intermittent dorsal displacement of the soft palate: A case-control study in 78 racing Thoroughbreds. In *Proceedings of the Congress of the British Equine Veterinary Association, Equine Veterinary Journal Ltd.* (p. 298).

Personal Communication: Reardon, R. (June 2010).