Maxillary nerve block within the pterygopalatine fossa for oral extraction of maxillary cheek teeth in 80 horses

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Summary: Based on the results of previous studies, the maxillary nerve block using the Extraperiorbital Fat Body Insertion (EFBI)-technique should provide anaesthesia of the maxillary cheek teeth with a minimized risk for complications. Clinical investigations were required to approve the practicability of the EFBI-technique performed on a greater number of standing, sedated horses; monitor possible risks and complications in patients; evaluate the analgesic effect achieved by the EFBI-technique; investigate a possible difference of effectiveness using two different volumes of local anaesthetic. Eighty horses were included in this blinded study and divided into two groups either receiving 2 or 4 ml lidocaine / 100 kg bodyweight for local nerve block. Maxillary cheek tooth extraction was performed thereafter in the standing, sedated horse. The local block using EFBI-technique was easy to perform in all horses and its practicability under clinical conditions was confirmed. A difference of analgesic effects using two different volumes of the local anaesthetic could not be detected. To minimize risks and complications, it is advisable to use the lower dose with 2 ml/100 kg bodyweight lidocaine.

Keywords: horse; equine dentistry; local anaesthesia; maxillary nerve block; EFBI-technique, cheek tooth extraction

Introduction

Extraction of teeth, especially cheek teeth, is a widely performed procedure in the treatment of severe dental and periodontal diseases in the horse (*Dixon* et al. 2000). Nevertheless, equine dental surgeries are associated with a high rate of complications compared to other surgical procedures (*Prichard* et al. 1992). Conventional tooth removal techniques (e.g. repulsion, classical buccotomy) usually require general anaesthesia and are often followed by postoperative complications (*Dixon* et al. 2000). Consequently, exodontia techniques that are performed in the standing, sedated horse have been enhanced and successfully applied over the last years (*Tremaine* 2007). Local or regional anaesthesia plays an important role in reducing risks and financial costs associated with general anaesthesia and recovery (*Bardell* et al. 2010). Regional nerve blocks are the key to successfully perform dental extractions in the standing horse in combination with the use of potent sedative and analgesic drugs (*Rawlinson* 2011).

Local nerve blocks are easy to perform and usually well tolerated by horses. Less sedation is required during dental procedures when local anaesthesia is successfully obtained (*Fletcher* 2004). Without the use of regional nerve blocks in conscious horses, the successful tooth extraction relies much on the cooperation of calm horses, in conjunction with the use of very high doses of intravenous sedatives and uncomplicated extraction procedures (*Rawlinson* 2011).

The maxillary nerve block provokes analgesia of the maxillary cheek teeth and paranasal region (*Moyer* et al. 2011). The maxillary nerve branches from the fifth cranial nerve within the pterygopalatine fossa enters the maxillary canal by passing through the maxillary foramen. Within the maxillary canal alveolar branches are innervating the maxillary cheek teeth and their periodontium (*Easley* 1996).

Vlaminck and *Steenhaut* (2001) and *Fletcher* (2004) suggested anaesthetizing the maxillary nerve caudal from the maxillary foramen; this technique is known as Maxillary Foramen Block. Therefore, a spinal needle is inserted into the pterygopalatine fossa, just ventral to the zygomatic arch until the needle tip contacts the perpendicular plate of palatine bone. The maxillary nerve is blocked with up to 20 ml lidocaine. This technique (designated as Palatine Bone Insertion (PBI)-technique" according to *Staszyk* et al. [2008]) has a high risk for puncturing blood vessels and nerves. Several complications, such as hematoma, exophthalmos and blindness are described after application of this technique (*Bienert* et al. 2011). Therefore *Staszyk* et al. (2008) modified the method. With the Extraperiorbital Fat Body Insertion (EFBI)-technique the needle is inserted less deeply and the local anaesthetic is injected into the extraperiorbital fat body. The study of *Staszyk* et al. (2008) using cadaveric heads demonstrated that accidental puncturing of relevant anatomical structures is avoided. In this study a volume of 10 ml was as effective as a volume of 20 ml in terms of spreading of the medium and consistent distribution around the maxillary nerve (*Staszyk* et al. 2008). However, sufficient regional anaesthesia and analgesia using this EFBI-technique could only be assumed by the results of this study.

Therefore evaluation of the EFBI-technique was performed in order to assess effectiveness and risks under clinical conditions. *Rieder* et al. (2016) confirmed in an experimental trail that the EFBI-technique is feasible. The results of this study indicated that a dose of 2 ml/100 kg BW lidocaine might be sufficient. However, due to deep sedation of their horses, a

general appraisement for sufficient analgesia of the maxillary cheek teeth with the performed tests was not possible.

Clinical investigations in the context of maxillary cheek tooth extraction would be beneficial to further confirm these results. Hence, the present clinical study with the following aims was designed:

- Evaluating the practicability of the EFBI-technique performed in the standing, sedated horse undergoing a maxillary cheek tooth extraction,
- Evaluating the analgesic effect achieved by the EFBI-technique,
- Evaluating a possible discrepancy of effectiveness using two different volumes of local anaesthetic, Monitoring of possible risks and complications during and after the performance of the local anaesthesia.

Material and Methods

Animals

Eighty horses (40 geldings, 39 mares, one stallion; 27 different breeds; 5 to 24 years old) were used for this study. All horses were presented to the Veterinary Clinic Gessertshausen for cheek tooth extraction (e. g. due to tooth fracture, periodontitis, open pulp, apical infections).

Study design

In all 80 horses unilateral maxillary cheek tooth extraction was necessary. First attempt was the removal of the tooth by oral extraction; if this method failed, the tooth was removed by minimally invasive buccotomy or expulsion using a Steinmann-Pin.

The study was designed as a randomized, prospective, blinded, clinical trial. With the help of a consecutively numbered list, horses were divided into two groups of 40 animals. Group 1 achieved 2 ml/100 kg bodyweight of local anaesthetic, Group 2 achieved 4 ml/100 kg bodyweight of local anaesthetic for the local nerve block. A first, non-blinded investigator (A) performed all maxillary nerve blocks under comparable conditions whereas a second, blinded investigator (B) made all study-related measurements.

Baseline measurements of heart and respiratory rate were performed (investigator B) after entering the examination room and before sedation. Thereafter horses were sedated using a combination of detomidine (0.02−0.04 mg/kg; Domosedan®, Pfizer, Berlin, Germany) and butorphanol (0.1 mg/kg; Torbugesic®, Fort Dodge, Würselen, Germany).

Nerve block

The maxillary nerve block was performed using the Extraperiorbital Fat Body Insertion (EFBI)-technique according to recommendations of *Staszyk* et al. (2008). The puncture site was determined 10 mm ventral to the zygomatic arch at a transversal plane between the middle third and the caudal

third of the eyeball. Insertion was performed at a 90° angle to the surface of the skin. A 0.9 × 90 mm, 20 G × 3 1/2 ″ spinal needle (Neoject®, Dispomed Witt oHG, Gelnhausen, Germany) was forwarded through the masseter muscle. After passing the intersection between the masseter muscle and the extraperiorbital fat body, the needle was advanced another centimeter. After ensurance of the correct needle position the lidocaine was injected into the fat body within the pterygopalatine fossa.

Oral extraction started ten minutes after performing the local nerve block. The extraction of the diseased maxillary cheek tooth was performed according to recommendations of *Lowder* (1999). In cases of complications, e.g. fracturing the diseased tooth with retention of apical fragments, the oral extraction was stopped and expulsion by Steinmann-Pin or minimally invasive buccotomy was performed.

Measurements

Complications regarding the performance of the nerve block (aspiration of venous blood, occurrence of turgor ventral of the zygomatic arch, dorsal of the eye within the range of the supraorbital fossa and within the range of the palpebra) as well as acceptance of lidocaine injection by the horses (obvious lifting of the head, chewing, tremor of the head, tremor of the head in combination with chewing, stamping with front leg) were recorded.

Before and five minutes after performing the local block, a Schirmer Tear Test was performed on the side of the head the dependent tooth was extracted.

Further, investigator B (blinded) tested pain sensation by using two experimental settings at these time points:

- A mechanical stimulus was produced with a 22 G × 1¼″, 0.7 × 30 mm needle (Neoject®, Bela-pharm, Langförden, Germany) on the palatale gingiva in the area of the maxillary cheek tooth that had to be extracted. The needle was stung into the gingiva five times with a depth about 1−3 mm.
- A thermal stimulus was set on the occlusal surface of the dependent tooth using cooling spray (Sport Cooling Spray®, Henry Schein, Gillingham, UK). A small plastic tube (6 centimeter length) enabled local spraying on the occlusal surface of the dependent tooth for five seconds.

Parameters for defending reactions as headbanging or chewing were scored from 0 to 2 (no reaction [0], chewing [1], headbanging [2]).

Before and during surgery the heart and respiratory rate as well as occurrence, type and number of defense reactions (headbanging, headshaking, stepping forward or backward) and behaviour of the horses were recorded every five minutes.

Degree of sweating was assessed using a scoring system from 0 to 3 (no [0], lightly [1], moderate [2], heavy [3]). Reaction of the pupils was classified in two categories (no reaction [0], mydriasis [1]). Degree of chewing was graded using a scoring system from 0 to 3 (no [0], lightly [1], frequently [2], strong

and frequently [3]) and amount of vocalization was classified in three categories (groaning [1], neighing [2], snorting [3]).

Follow-up examinations

Penicillin combined with streptomycin 20.000 I.E./kg BW i.m. (Veracin-compositum®, Fa. Albrecht, Aulendorf, Germany) and flunixin-meglumine 1.1 mg/kg BW i.v. (Paraflunixin®, IDT, Rodleben, Germany) were administered to all horses for three to five days. During the first four days after extraction clinical examination was performed daily especially looking for swelling or secondary bleeding of the injection site. The periocular area was monitored regarding blepharospasm, miosis, or swollen palpebrae.

Statistical analysis

The division of the incidents and complications during the performance of the local nerve block was analyzed for differences between the low and high volume of lidocaine using the Chi-Square-Test. Differences were considered significant for $p < 0.05$.

The frequency distribution of the mild defense reactions that occurred during testing pain sensation was analyzed for differences before and after the local nerve block using the Chi-Square-Test and the Mc-Nemar s-Test.

The scores of each defense reaction and behaviour of every horse during the oral extraction were analysed for differences between the lower and higher volume of lidocaine using the Wilcoxon-paired test and the Chi-Square-Test. Differences were considered significant for $p < 0.05$.

Results

Maxillary nerve block

Procedure and reactions of the horses

In 74 of 80 horses (92.5%) the maxillary nerve block was set within the first attempt. In 4 horses (5%) a nose-twitch was necessary for a safe performance of the local nerve block and in 2 horses (2.5%) a repositioning of the spinal needle was necessary.

Sixty-five of the horses (81.3%) showed no adverse reaction during needle placement or lidocaine injection. The remaining 15 horses showed mild to moderate reactions as shown in Figure 1.

Complications during the performance of the nerve block

In 65 horses maxillary nerve block caused no further complication. In the remaining horses (15 out of 80; 18.7%) following complications occurred during or right after the nerve block:

Blood aspiration in 13 horses, 6 horses of group 1 and 7 horses of group 2. A correct repositioning of the spinal needle was done before injecting lidocaine:

Group 1: six horses: Two horses showed mild chewing during the injection
Group 2: seven horses: Two horses showed mild chewing during the injection. After the nerve block another three horses developed an articulate swelling dorsal the eye within the area of the supraorbital fossa. These three horses did not show any signs of pain palpating the swollen area. After the surgical intervention was finished they got a cold and wet compression bandage over the swollen area for the next 24 hours. In all cases the swelling disappeared within three days.

In two experiments horses developed a diffuse turgor:

Group 1: One horse ventral of the zygomatic arch
Group 2: One horse dorsal to the eye within the range of the upper palpebrae a few minutes after the nerve block.

Lacrimation rate

Schirmer Tear Test was performed in 51 horses (63.7%). There were no significant differences between the lacrimation rate before and after local anaesthesia although there was a trend for a decrease of lacrimation rate after local anaesthesia (Figure 2).

Reaction of the pupil

In 21 horses (26.3%) a moderate mydriasis occurred after the nerve block. In horses of group 1 (10 of 21) mydriasis lasted for a mean time of 17 minutes whereas in horses of group 2 (11 of 21) mydriasis lasted for more than 21 minutes. In 2 horses the pupil was normal sized again before starting dental extraction and in the remaining 19 horses pupil was normal sized at the end of extraction procedure.
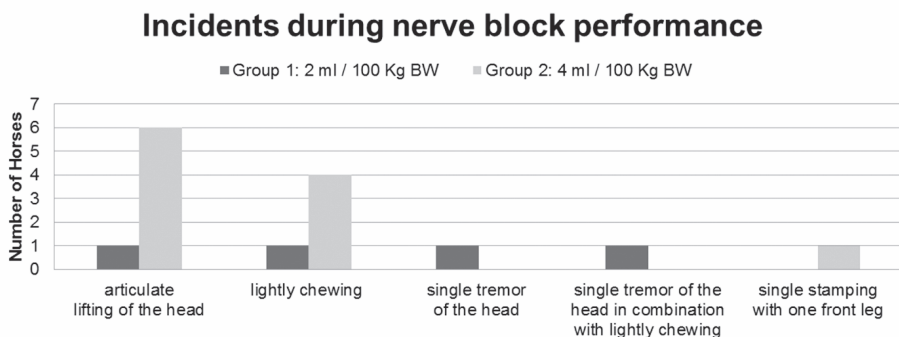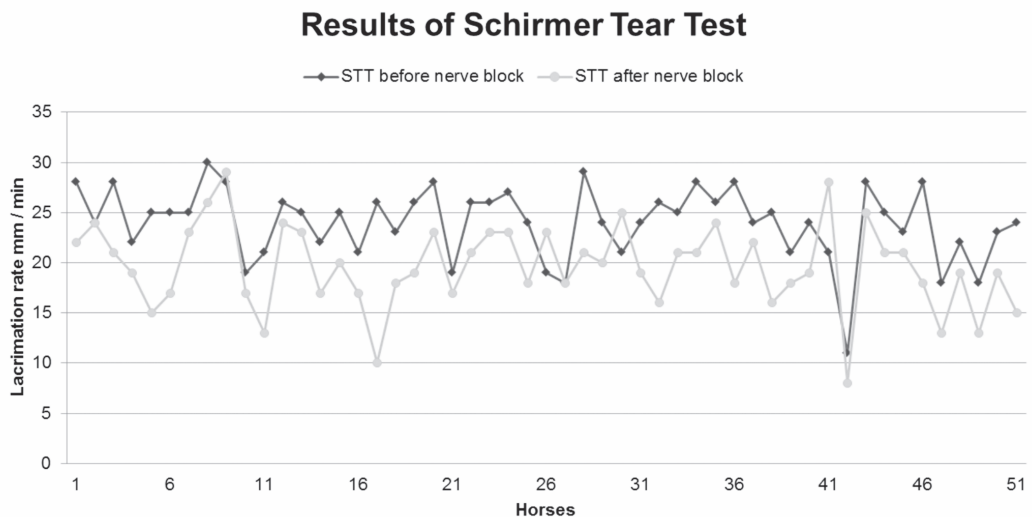

Incidents during nerve block performance

■ Group 1: 2 ml / 100 Kg BW   ■ Group 2: 4 ml / 100 Kg BW

Fig. 1 Incidents during nerve block performance of 80 sedated horses (group 1: 2 ml/100 kg BW lidocaine and group 2: 4 ml/100 kg BW lidocaine)
Unerwünschte Vorfälle während der Durchführung der Leitungsanästhesie an 80 sedierten Pferden (Gruppe 1: 2 ml Lidocain/100 kg Körpergewicht und Gruppe 2: 4 ml Lidocain/100 kg Körpergewicht)

Fig. 2 Results of Schirmer Tear Test (n = 51) in mm/min before and after maxillary nerve block (above); lacrimation rate comparative after maxillary nerve block (below) *Ergebnisse des Schirmer-Tränen-Tests (n = 51) in mm/Minute vor und nach der Lokalanästhesie des N. maxillaris (oben); Lakrimationsrate vergleichend nach der Lokalanästhesie des N. maxillaris (unten)*

Results of Schirmer Tear Test

— STT before nerve block   — STT after nerve block

(Line chart: Lacrimation rate mm / min (y-axis, 0–35) vs. Horses (x-axis, 1–51))

Clinical examinations

Cardiorespiratory parameters
There was no significant change in heart or respiratory rate during performance of the nerve block and during surgical procedure in both groups.

Testing pain sensation
Results were analyzed referenced to the particular group; the results were not significant.

Mechanical stimulus before and after nerve block
Group 1: 40% (16 out of 40) of the horses were tested.
Group 2: 37.5% (15 out of 40) of the horses were tested.

Thermal stimulus before and after nerve block:
Group 1: 60% (24 out of 40) of the horses were tested.
Group 2: 47.5% (19 out of 40) of the horses were tested.

The defense reactions of Group 1 compared to Group 2 are illustrated in Figure 3.

Oral extraction

The dental extraction via oral extraction, buccotomy or repulsion was successful in 78 horses. In the remaining two horses (2.5%) the oral extraction was not possible due to the underlying pathology of the tooth. In these two horses extraction was performed under general anaesthesia at the next day.
Defense reactions

There were no significant differences in headbanging, headshaking, stepping forward and backward (Figure 4) or in amount of chewing (Figure 5) between groups.
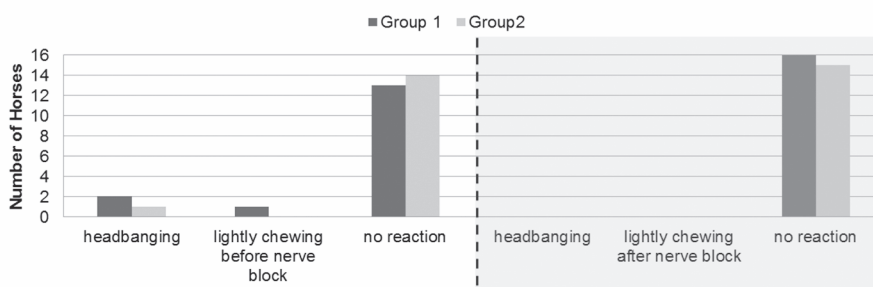
Vocalization: There was no significant difference between Group 1 and 2.
Forty-four horses showed mild to moderate sweating (55%) during the surgical procedure. There were no significant differences between groups.

Follow-up Examinations
Most horses showed no signs of clinical complications regar-

Mechanical stimulus: reactions

■ Group 1   ■ Group2

(Bar chart: Number of Horses (y-axis, 0–16). Before nerve block: headbanging, lightly chewing, no reaction. After nerve block: headbanging, lightly chewing, no reaction.)

Thermal stimulus: reactions

■ Group 1   ■ Group2

(Bar chart: Number of Horses (y-axis, 0–20). Before nerve block: headbanging, lightly chewing, no reaction. After nerve block: headbanging, lightly chewing, no reaction.)
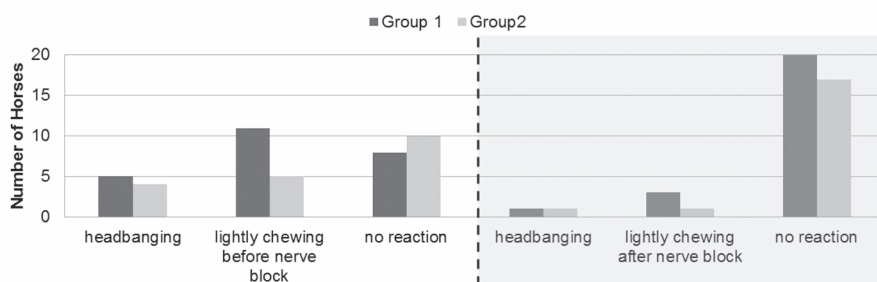
Fig. 3 Defense reactions during the mechanical and thermal stimuli before (white & left) and after (grey & right) maxillary nerve block (group 1: 2 ml/100 kg BW lidocaine and group 2: 4 ml/100 kg BW lidocaine) *Abwehrbewegungen während der mechanischen und thermischen Stimulation vor (weiß & links) und nach (grau & rechts) der Lokalanästhesie des N. maxillaris (Gruppe 1: 2 ml Lidocain/100 kg Körpergewicht und Gruppe 2: 4 ml Lidocain/100 kg Körpergewicht)*
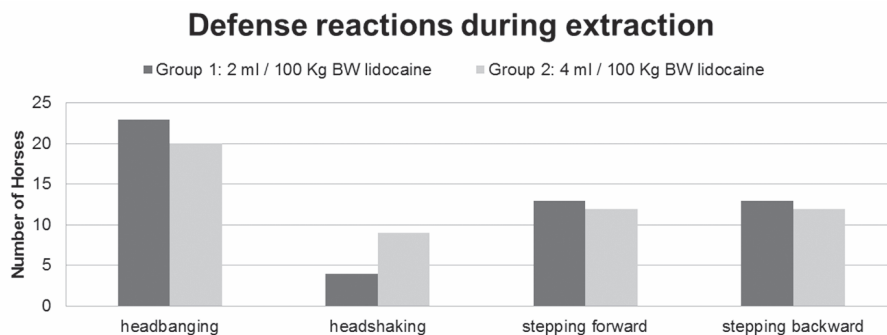
Defense reactions during extraction

■ Group 1: 2 ml / 100 Kg BW lidocaine   ■ Group 2: 4 ml / 100 Kg BW lidocaine

Fig. 4   Number of horses with defense reactions during extraction (group 1: 2 ml/100 kg BW lidocaine and group 2: 4 ml/100 kg BW lidocaine)
Anzahl der Pferde mit Abwehrverhalten während der Extraktion (Gruppe 1: 2 ml Lidocain/100 kg Körpergewicht und Gruppe 2: 4 ml Lidocain/100 kg Körpergewicht)

Chewing during extraction

■ Group 1: 2 ml / 100 Kg BW lidocaine; 36 out of 40 horses showed this behaviour
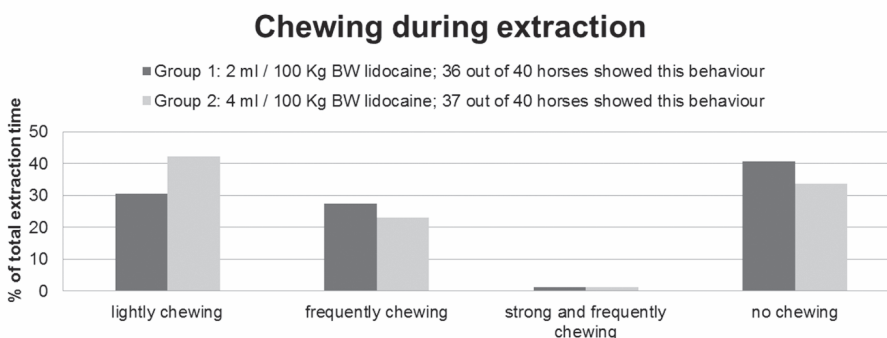■ Group 2: 4 ml / 100 Kg BW lidocaine; 37 out of 40 horses showed this behaviour

Fig. 5   Duration of chewing during extraction compared to total extraction time (group 1: 2 ml/100 kg BW lidocaine and group 2: 4 ml/100 kg BW lidocaine)
Dauer des Kauverhaltens während der Extraktion im Vergleich zur gesamten Extraktionsdauer (Gruppe 1: 2 ml Lidocain/100 kg Körpergewicht und Gruppe 2: 4 ml Lidocain/100 kg Körpergewicht)

ding local anaesthesia after surgery. In five horses (one in group 1 and four in group 2) complications occurred:

Group 1: One horse showed a diffuse turgor ventral of the zygomatic arch; the horse did not show any signs of pain during palpating and clinical symptoms disappeared within two days without any treatment.

Group 2: Three horses with articulate swelling dorsal of the eye at the area of the supraorbital fossa developed superficial corneal ulcerations at the dependent eye. Horses were treated with antibiotic eye ointment and recovered within three weeks. One horse showed a diffuse turgor dorsal of the eye within the area of the upper palpebrae; the horse did not show any sign of pain during palpating and symptoms disappeared within two days.

Discussion

Techniques for oral tooth extraction were first described by *Merillat* (1906). The transoral extraction should be the first method of choice chosen by veterinarians. Although a retrograde approach to the sinus or periradicular area may be necessary to treat an existing secondary disease, oral extraction should be attempted first (*Easley* 2011). The possibility to perform the oral extraction in the standing horse has considerable advantages over other techniques. Despite an increased injury risk to stuff, the more comfortable position for the surgeon in front of the standing horse and the lower risk for bleeding are some advantages of sedation compared to general anaesthesia. Further risks associated with induction and recovery is lower in standing horses as well as a reduced time to complete the procedure, and reduced costs (*Doherty* and *Valverde* 2006).

Surgery in standing horses requires local anaesthesia (*Day* and *Skarda* 1991). Sufficient analgesia of the cheek teeth is necessary for advanced dental procedures performed in standing, sedated horses (*Fletcher* 2004). Desensitizing the maxillary branch of the trigeminal nerve is useful for surgical procedures involving the upper (cheek) teeth, paranasal sinuses, maxilla and oral cavity (*Newton* et al. 2000) and is achieved by local blocking the maxillary nerve within the pterygopalatine fossa (*Bienert* et al. 2011).

Rieder et al. (2016) verified that the maxillary nerve block performed with the EFBI-technique is a feasible clinical technique and the present study demonstrated the practicability of the EFBI-technique under clinical conditions. Only four horses required additional nose-twitch to sedation for better performance of the local nerve block. Mild reactions during needle insertion such as headshaking or stamping with a front leg appeared and were easy to handle.

Testing the analgesic effectiveness of the EFBI-technique during surgery necessitated parameters of behaviour and defense reactions of horses which could be related to pain sensation. Non-specific and specific behaviour patterns are described which are related to different conditions of pain in horses. The frequency of showing specific behaviour pattern can be used to evaluate the intensity of pain (*Ashley* et al. 2005). Cardiorespiratory parameters were monitored every five minutes. However, respiratory and heart rate, although often used as main indicators for pain, only have a moderate sensitivity and specificity. Using only these two parameters it is not possible to evaluate the degree of pain (*Bohnet* 2010). In the present clinical trial respiratory and heart rate decreased after sedation, which could be related to the depressant effect of detomidine (*Tobias* 2004). During setting the local nerve block and tooth extraction there was no alteration of these

two parameters, indicating no sensation of pain or stress in our horses.

Bohnet (2010) showed that the reaction to touching the painful area, followed by pawing, head movements and kicking against the belly are sensitive, specific, and repeatable parameters for the detection of pain in horses. Regarding this, the behaviour typical for defense reactions in horses and often seen during the examination of the head (headbanging, headshaking, chewing, stepping forward, or stepping back) was used in the present study to interpret pain sensation.

Rieder et al. (2016) evaluated two methods (mechanical and thermal stimuli) for testing pain sensation of teeth and gingiva in horses. Using this experimental setup in the present study, pain sensation was tested before tooth extraction in some horses of both groups. The results showed that the mechanical stimulus did hardly cause any reactions. Furthermore, in contrast to the study of *Rieder* et al. (2016), the thermal stimulus resulted in less defense reactions after local anaesthesia in both groups. The larger number of horses in the present study could have influenced the results. Another reason could be that horses in our study received the opioid butorphanol in addition to detomidine. The onset of action of butorphanol in the horse is immediately after intravenous injection (*Sellon* et al. 2001). Therefore not only local anaesthesia, but also the analgesic effect of butorphanol may have influenced pain sensation. With the horses undergoing a maxillary cheek tooth extraction in the present study, deeper structures (e. g. the periodontal ligament) than only the gingiva and the occlusal surface of the tooth are suitable for evaluating the analgesic effect. Summarized, the results confirmed the prementioned statement of *Rieder* et al. (2016): General appraisement for sufficient analgesia of the maxillary cheek teeth with the two tests could not be attained. Probably there is no feasible method to verify the onset of action of the local nerve block before starting surgical intervention.

The results of the parameter chewing demonstrated that most of the horses in both groups showed either no chewing or weak to medium chewing during the surgical intervention. It is possible that the few horses showing massive chewing reacted sensitive to any kind of tangency in and around the mouth. Despite deep sedation, these horses were very nervous compared to others and probably showed this behavior independent to any painful stimulus. It is questionable whether this parameter could be related to the intensity of pain. Nevertheless, there were no significant differences between Group 1 and Group 2 showing that chewing and vocalization are specific and individual behaviour patterns that cannot be used to evaluate pain sensation during tooth extraction.
In some horses headbanging and headshaking showed similar results compared to chewing. In these rare cases it was obvious that the frequency of these two parameters increased because these horses were timid or reacted very sensitive to any kind of stimulus in and around the oral cavity. Further it must be considered that the intensity of pain-specific behaviour patterns are influenced by many factors as underlying illness, age, breed, character and temperament of the horse, earlier experiences with pain and therefore associated avoidance behaviour, and the relationship between human and animal (*Bohnet* 2010). But overall, headbanging and headshaking were shown mostly directed to an action during surgery (e.g. the force during inter-

dental spreading). Stepping forward or back occurred only occasionally and without differences between groups, but most of the time in direct relation to the prementioned surgical intervention. Consequently, in this study the parameters "headbanging", "headshaking", "stepping forward", and "stepping back" turned out to be designative behaviour patterns when perceiving pain during dental surgery.

There were no significant differences between the horses in group 1 (2 ml/100 kg BW lidocaine) and group 2 (4 ml/100 kg BW lidocaine) concerning the defense reactions and behaviour during the injection of the lidocaine, the complete surgical procedure or regarding the tests for pain sensation. Different data related to the required volume of lidocaine for effective maxillary nerve block in horses are published. Typical volumes recommended are ten to thirty ml per horse (*Stephenson* 2004, *Dixon* 2006, *Tremaine* 2007a). The technique to block the maxillary nerve within the pterygopalatine fossa suggested by *Vlaminck* and *Steenhaut* (2001) and by *Fletcher* (2004) demanded up to 20 ml lidocaine for infiltration. The study of *Staszyk* et al. (2008) with cadaveric heads demonstrated that in all computed tomographic simulations the injected contrast medium surrounded the maxillary nerve in the pterygopalatine fossa independent from the insertion technique (EFBI or PBI) or the volume of the contrast medium (10 ml or 20 ml). The results of the present study demonstrated that the smaller amount of lidocaine was sufficient to guarantee good analgesia of the maxillary cheek teeth.

Furthermore, this study showed that complications after local nerve block using a smaller volume appeared rarely compared to the larger volume. Although clinical signs for retrobulbar hematoma or other reported severe complications ranging from collapse (possibly as a result of intravascular injection of local anaesthetic) to blindness after introducing infection into retrobulbar tissues (*Dixon* 2006, *Staszyk* et al. 2008), were not seen in the present study, three horses of group 2 (large volume lidocaine) developed articulate swelling dorsal of the eye within the range of the supraorbital fossa and, as a possible result, a superficial ulcer. In two other horses of group 2 a diffuse subcutaneous swelling appeared ventral to the zygomatic arch or dorsal to the eye. A trauma to the transverse facial or maxillary vessels may result in hematoma formation causing mild to marked periocular or retrobulbar swelling, although such swelling is usually cited as being self-limiting and transient (*Edwards* 1930, *Fletcher* 2004, *Gerard* 2007, *Tremaine* 2007).

In addition, as the clinical trial of *Rieder* et al. (2016) already confirmed, all horses with eye related complications in the present study showed decrease lacrimation after the local nerve block. The maxillary nerve block can cause a decrease of the lacrimation fluid by anaesthetizing the lacrimal nerve (*Nickel* et al. 1992). A reduction in tear production has been recognized as a common cause of corneal and conjunctival lesions in both humans and animals (*Gelatt* 2007). The results of the Schirmer tear test demonstrated that independent from the volume of lidocaine 88.2 % of the horses showed a decrease lacrimation after the nerve block. Thus, the decrease of lacrimation rate could possibly support the development of corneal ulcerations. Preventive application of eye drops or eye ointment is recommended to prevent or minimize these symptoms.

Conclusions

The maxillary nerve block using the EFBI-technique was successful in all horses and is a highly practicable clinical method. The veterinarian should be experienced and aware of the anatomic structures of the targeted area. For the performance of the nerve block the horse has to be sedated and if necessary the head has to be fixed by a second person. Aspirating before injecting the local anaesthetic minimizes complications.

With the used pain sensation methods, there is no warranty to verify the onset of action of the local nerve block before starting oral extraction. Further tests for the evaluation of the efficacy of analgesia in maxillary cheek teeth need to be defined. Using 2 ml / 100kg BW lidocaine provides safe and effective regional anesthesia while extracting maxillary cheek teeth and reduces the risks of anaesthesia related complications. By reason of decrease of tear production, a preventive treatment with eye ointment is recommended.

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Erweiterte Zusammenfassung

Anästhesie des N. maxillaris in der Fossa pterygopalatina zur Extraktion maxillärer Backenzähne bei 80 Pferden

Die Anästhesie des N. maxillaris in der Fossa pterygopalatina wurde bereits in vorangegangenen Studien auf Durchführbarkeit, Wirksamkeit und Risiken untersucht. Die Anästhesie des N. maxillaris mittels der Extraperiorbitalen Fettkörper Technik (EFBI) soll eine Anästhesie der maxillären Backenzähne mit einem verringerten Risiko für Komplikationen gewährleisten.

Um diese These zu bestätigen sind weitere klinische Erhebungen notwendig. Die vorliegende Arbeit zielte zum einen darauf ab, die Praktikabilität der EFBI-Technik an einer größeren Anzahl von Pferden in der täglichen Praxis zu erproben. An den Tieren wurde nach vorangegangener Diagnose- und Indikationsstellung die Extraktion eines maxillären Backenzahnes unter Sedierung vorgenommen. Zum anderen sollten mögliche Risiken und Komplikationen, die diese Form der Leitungsanästhesie bergen kann, unter realen klinischen Bedingungen erfasst werden. Des Weiteren sollte der anästhetische Effekt, der durch die EFBI-Technik erreicht wird, evaluiert werden und ein möglicher Unterschied der Wirksamkeit bei Verwendung zweier verschiedener Mengen des Lokalanästhetikums untersucht werden.

In diese verblindete, randomisierte und prospektive Studie wurden achtzig Pferde aufgenommen. Die Tiere wiesen unterschiedliche Alter, Rassen und Geschlechter auf und wurden alle für eine unilaterale, maxilläre Backenzahnextraktion vorstellig. Die Pferde wurden mithilfe einer fortlaufend nummerierten Liste vorab in zwei Gruppen zu je vierzig Pferden aufgeteilt und erhielten entweder 2 ml/100kg Körpergewicht Lidocain (Gruppe 1) oder 4ml/100kg Körpergewicht Lidocain (Gruppe 2). Die Anästhesie des N. maxillaris wurde mittels EFBI-Technik nach *Staszyk* et al. (2008) vorgenommen. Abwehrbewegungen der Pferde und Nebenwirkungen während und im Anschluss an die Anästhesie wurden dokumentiert. Bei 51/80 Pferden wurde fünf Minuten vor und nach der Leitungsanästhesie ein Schirmer Tränentest zur Messung der Tränenflüssigkeitsproduktion am Auge der anästhesierten Seite durchgeführt. Zu diesen beiden Zeitpunkten testete der verblindete Untersucher ebenfalls die Schmerzausschaltung an den Zähnen und der umliegenden Gingiva durch mechanische und thermische Stimuli nach dem Vorgehen von *Rieder* et al. (2016). Während der Tests wurden Abwehrreaktionen der Pferde dokumentiert. Die anschließende orale Extraktion des maxillären Backenzahnes wurde nach *Lowder* (1999) durchgeführt. Misslang die orale Extraktion wurde der Zahn mittels minimalinvasiver Bukkotomie oder Expulsion via Steinmann-Pin entfernt. Kardiorespiratorische Parameter (Herz- und Atemfrequenz), Abwehrreaktionen der Pferde (Kopfschlagen, Kopfschütteln, Vor- und Zurücktreten), Schwitzen, Reaktionen der Pupillen, Leerkauen und Lautäußerungen vor und während des operativen Eingriffs wurden alle fünf Minuten dokumentiert. Die ersten vier Tage nach der Extraktion wurden täglich klinische Untersuchungen mit besonderem Augenmerk auf Schwellungen oder sekundäre Blutungen im Injektionsbereich vorgenommen. Der okuläre Bereich wurde auf Blepharospasmus, Miosis oder geschwollene Lider hin kontrolliert. In der vorliegenden Studie konnte die Leitungsanästhesie des N. maxillaris bei 74 von 80 Pferden im ersten Versuch durchgeführt werden. Vier Pferde benötigten zusätzlich das Anlegen einer Nasenbremse und bei zwei Pferden musste die Injektionskanüle neu platziert werden. Kein Abwehrverhalten während der Anästhesie zeigten 65 der 80 Pferde; die verbliebenen 15 zeigten moderate Abwehrreaktionen. Bei ebenfalls 65 Pferden wurden keine Komplikationen durch die Leitungsanästhesie vermerkt.

Ohne einen feststellbaren signifikanten Unterschied zwischen Gruppe 1 (geringere Menge Lidocain) und Gruppe 2 (größere Menge Lidocain) war bei 13 der verbliebenen Pferde eine Reposition der Injektionskanüle nach Blutaspiration notwendig, bei zwei Tieren trat eine diffuse Schwellung im Injektionsbereich auf.

Die Ergebnisse des Schirmer Tränen Tests zeigten keinen signifikanten Unterschied hinsichtlich des Tränenflusses auf, obwohl eine Tendenz zur Abnahme des Tränenflusses nach der Leitungsanästhesie zu erkennen war. In beiden Gruppen war außerdem bei einigen Pferden eine geringgradige Mydriasis nach der Leitungsanästhesie zu beobachten, die jedoch bei fast allen Tieren bis zum Ende des Eingriffs wieder verschwunden war. Des Weiteren wurde in beiden Gruppen kein signifikanter Unterschied der Herz- und Atemfrequenz während der Leitungsanästhesie und des operativen Eingriffs festgestellt. Die Ergebnisse der Überprüfung der Schmerzausschaltung mittels thermischem und mechanischem Reiz zeigten keinen signifikanten Unterschied zwischen den Gruppen. Die Abwehrbewegungen der Pferde während der Operation wiesen keinen signifikanten Unterschied zwischen beiden Gruppen auf. Eine Extraktion des Zahnes mittels oraler Extraktion, minimalinvasiver Bukkotomie oder via Steinmann-Pin gelang bei 78 der Pferde. Bei den verbliebenen beiden Tieren wurde der Zahn am darauffolgenden Tag unter Allgemeinanästhesie entnommen. Postoperationem traten bei fünf Pferde geringgradige Komplikationen auf, die mit der Leitungsanästhesie des N. maxillaris in Zusammenhang gebracht werden konnten. Hierbei handelte es sich fast ausschließlich um Schwellungen im Bereich der Augenpartie oder oberflächliche Hornhautulzerationen auf der anästhesierten Seite. Pferde aus Gruppe 2 mit der größeren Menge Lidocain zeigten diese Symptome signifikant häufiger. Nach symptomatischer Behandlung mit Augensalben (lokal) und Antibiotika (systemisch) verschwanden die Symptome spätestens nach drei Wochen bei allen Tieren.

Die Anästhesie des N. maxillaris mittels der EFBI-Technik gelang bei allen Pferden und ist als gut durchführbare und erfolgreiche Methode für die tägliche Klinik anzusehen. Der Tierarzt sollte jedoch genaue Kenntnisse der anatomischen Strukturen des betreffenden Areals besitzen. Das Pferd sollte für die Leitungsanästhesie sediert sein und von einer zweiten Person am Kopf fixiert werden. Vor der Injektion des Lokalanästhetikums sollte aspiriert werden um mögliche Komplikationen zu minimieren. Die durchgeführten Tests zur Überprüfung der Schmerzausschaltung vor der Operation geben keine Garantie des Wirkungseintritts der Leitungsanästhesie. Für die Evaluierung der wirksamen Analgesie im maxillären Backenzahnbereich sind weitere Tests nötig. Die Verwendung von 2 ml/100kg Körpergewicht Lidocain ist ausreichend für die Extraktion maxillärer Backenzähne und reduziert die Risiken von Komplikationen durch die Leitungsanästhesie. Aufgrund der Abnahme der Tränenflüssigkeitsproduktion sollten präventiv Augensalben appliziert werden um die Hornhaut feucht zu halten.

Schlüsselwörter: Pferd, Pferdezahnheilkunde, Leitungsanästhesie, Anästhesie N. maxillaris, EFBI-Technik, Zahnextraktion