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The sheep head model for educational purposes in periodontal and oral surgery for dental undergraduates

Systematic review and laboratory investigation

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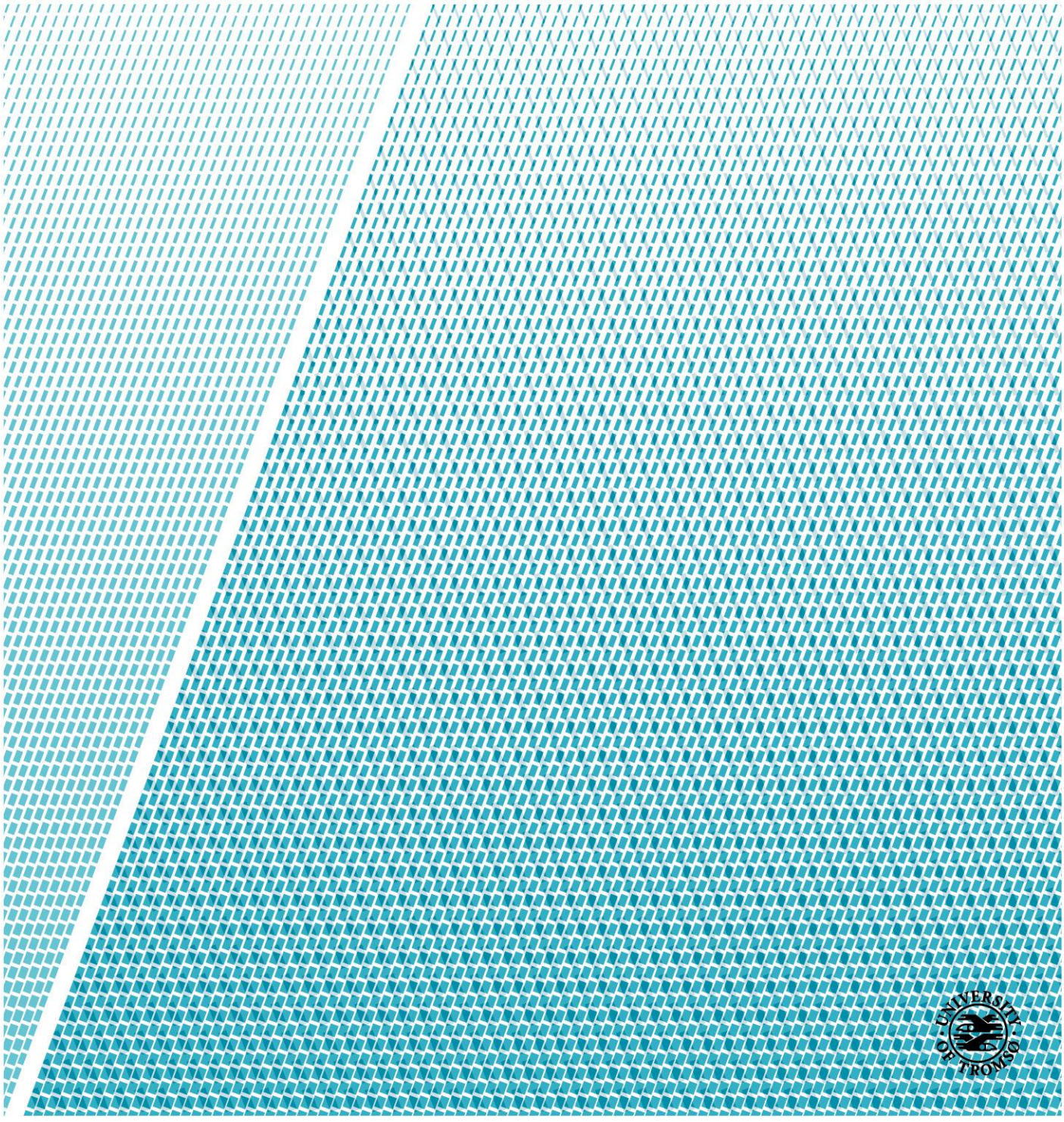

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1 Abstract

Background: Animal teaching models for a variety of surgical procedures in dentistry have been developed more than 50 years ago. In this study a systematic review was conducted to identify animal cadaver models and teaching outcome in regards to teaching dental undergraduates periodontal and oral surgery. The systematic review created a basis, and an examination of the sheep maxilla for its suitability as a teaching model was conducted. The procedures of choice include the most frequent procedures dental undergraduates could encounter.

Materials and method: A pre-established list of periodontal and oral surgical procedures was performed on a variety of sheep maxillas in different areas in the oral cavity. These surgical procedures are extraction, surgical removal of impacted tooth, tunnel preparation, a variety of sutures, procedure following sinus perforation, biopsy, hemisection and free gingival graft. Suitability for the respective surgeries and similarities to human conditions were addressed. Additionally, a step-by-step description along with pictures was made.

Results: The systematic review revealed that the use of animal models would benefit both undergraduates and graduates in regards of surgical skills, use of surgical equipments, as well as shortening of operation time. Pig and sheep heads are the most frequently used animal cadavers and provide the students with a realistic way of teaching surgical techniques and procedures. The model based on the sheep's maxilla is feasible and could supplement the mandible in the teaching of undergraduates in both periodontal and oral surgery. There are some surgical procedures addressed in this study that are not considered in previous studies included in the systematic review. These procedures are tunnel preparation, hemisection and a procedure following sinus perforation. However, most of the oral surgical procedures in this study have been performed only in pig models in previous studies.

Conclusions: This study shows that the sheep maxilla could be considered to be a promising teaching model for improving confidence and surgical skills in regards periodontal and oral surgeries performed by undergraduates in dental school institutions. Additional studies are needed to validate the sheep model within a teaching environment.

Keywords: "teaching", "periodontal", "surgery", "oral", "animal"

2 Introduction

In 2004, Al-Qareer et al. introduced a sheep cadaver model for teaching undergraduates' periodontal surgical procedures at the new dental school at Kuwait University. The main reason was that in a Muslim country, pigs were not available. Pig mandibles have been used for teaching purposes, in particular oral surgical procedures, since the 1960s. A couple of these published papers had been reviewed by Al-Qareer et al. (2004) who discussed some advantages of the sheep mandible for periodontal surgical teaching purposes (Stacey 1967, 1985, Bonnette and Hayward 1969). Later, a study by Larsen et al. (2013) was conducted, where the pig mandible was compared to the sheep mandible as regards suitability in teaching and training periodontal surgery to undergraduates.

2.1 Systematic review of animal models for teaching periodontal/oral surgical measures

A systematic review was performed in order to identify published papers on animal teaching models in oral and periodontal surgery. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines (Moher et al. 2009) were applied. Searches were conducted during the time period between 14th and 18th of January 2018. No date limits were applied for the search in order to obtain all relevant articles. In a modification of PICO, the focused question was: "Which animal models (problem) have been described for teaching/training (outcome) periodontal surgical or oral surgical methods (intervention)," regardless of any comparison.

The search was performed in PubMed and Google Scholar. PubMed was consulted first. A search using combinations of "teaching", "periodontal", "surgery", "oral", "animal" yielded:

("education"[Subheading] OR "education"[All Fields] OR "teaching"[All Fields] OR "teaching"[MeSH Terms]) AND periodontal[All Fields] AND ("oral surgical procedures"[MeSH Terms] OR ("oral"[All Fields] AND "surgical"[All Fields] AND "procedures"[All Fields]) OR "oral surgical procedures"[All Fields] OR ("surgery"[All Fields] AND "oral"[All Fields]) OR "surgery oral"[All Fields]) AND ("animals"[MeSH Terms:noexp] OR animal[All Fields])

There were 40 hits.

Next, Google Scholar was used to identify quotations of the four papers by Al-Qareer et al. (2004), Stacey (1967, 1985), and Bonnette and Hayward (1969). Number of quotations identified were; 18 quotations of the paper by Al-Qareer et al. (2004), 6 quotations of the paper by Bonnette and Hayward (1969), 4 quotations of the paper by Stacey (1967) and 3 quotations of the paper by Stacey (1985).

A final hand search through bibliographies of relevant articles was conducted in order to accumulate as much information as possible about animal models used for teaching purposes.

Inclusion criteria were met if: 1) the abstract made any discussion on animal models as a teaching method in periodontal and/ or oral surgery; 2) full article in English language was available; 3) the animal model had specific features that made it a unique and valuable tool in teaching undergraduates and/ or graduates in periodontal and/ or oral surgery; 4) the animal model showed that the practical execution of surgical procedures/ techniques helped to improve skills and confidence in the practice among undergraduates and/ or graduates. Records were excluded if one of the following criteria pertained: 1) languages other than English; 2) no description of any animal models; 3) if the animal model was used in other purposes than teaching.

After identifying records through database searching and through other sources, a total of six duplicates were excluded. Total records to be screened after duplicates removed were a total of 69 articles. After screening the 69 articles by titles, a total of 51 articles were excluded. Full-text articles to be assessed for eligibility were a total of 18 articles.

Of the 18 articles assessed for eligibility, two articles were excluded due to foreign language ("*The initiation to periodontal surgery" and "[Approach to periodontal surgery – training in periodontal surgery using pigs]*."), exclusion criteria number 2. One article ("Validity and Variability of Animal Models Used in Dentistry") was excluded because it comprised the exclusion criteria number 3. Three articles ("A laboratory for teaching oral-surgical technique," "Surgical Handicraft: Teaching and Learning Surgical Skills" and "A method for teaching the classical inferior alveolar nerve block") were excluded because the animal model was not described (exclusion criteria 1 and/ or 3).

Of these 18 articles, 12 were synthesized in the qualitative analysis (**Fig. 1**). These remaining 12 articles were relevant regarding the focus question.

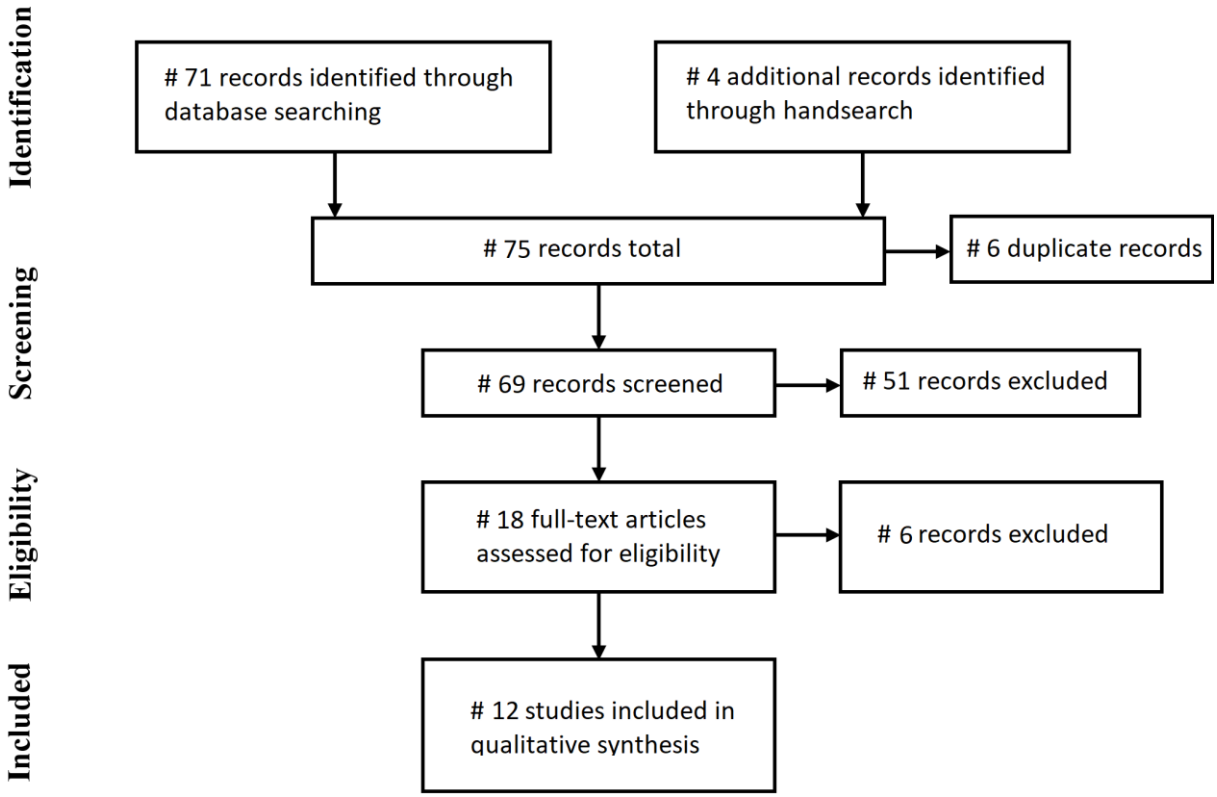


Fig 1. *Flow chart for record selection.*

All 12 studies included in the qualitative synthesis were read in full in order to extract information for the completion of **Table 1**.

Table 1: Overview of articles included in the systematic review

Article	Animal model	Surgery	Surgical procedures mentioned	Teaching outcome	Features of the animal model described
(Moore et al. 1965)	Pig	Oral	Mucoperiosteal flaps, cutting of alveolar bone, debridement and closure of wounds, use of forceps and elevators for extraction of teeth and retained roots, extraction of simple unerupted teeth, gingivectomy, alveolectomy, apicectomy and the marsupialization of dental cysts.	No teaching outcome described	Morphology and tissue textures
(Stacy 1967)	Pig	Oral	Injection technique, forceps extraction of teeth, surgical extraction of teeth, endodontic and apicectomy technique, gingival surgery, repair of soft tissue lesions, techniques for biopsy, removal of submaxillary salivary gland, fractures, closure of oro-antral fistulae, electro-cautery, surgical packs, removal of partly formed unerupted teeth and cleavage of bone	The pig's head is a realistic model which can provide as a teaching method in a wide range of basic oral surgery techniques. By including an animal model like this, the students are given a firm practical foundation which they may build their surgical skills and experience upon.	No specific features described
(Bonnette 1969)	Pig	Oral	Mucoperiosteal flaps, soft tissue handling, use of elevators, sectioning of multirooted teeth, forceps application, alveoloplasty and alveolectomy, debridement and wound management	Description of introductory course which has been included in the curriculum at the University of Michigan, School of Dentistry. The course includes; lectures, laboratory experience and clinical demonstrations of the surgical procedures. The pre-clinical preparation, which included an animal model, showed better levels of student achievement in the clinic.	No specific features described
(Cumming and Glavind 1972)	Pig	Periodontal	Local anaesthetic techniques, planning of surgical procedures, curettage, gingivectomy, reverse bevel flap, osseous contouring, suturing and placement of surgical dressings.	Using the pig mandible as a model for teaching periodontal surgery seems to improve both practical and theoretical abilities, including increased confidence among the students.	Quality of bone, tissue texture and occurrence of periodontal pathology
(Weissman 1988)	Pig	Periodontal	Local anaesthesia techniques, gingivectomy, crown lengthening, distal wedges, Widman flaps, osseous	Summarize that animal models have been proven to be beneficial in teaching undergraduate and	Morphology, tissue texture and occurrence of periodontal pathology.

			surgery, suturing and placement of surgical dressings.	graduate dental curriculum. Important aspects mentioned include: practice with various surgical instruments, increased confidence among students, to learn how the tissue responds, similarities with humans, surgical procedures, and other advantages regarding the pig specimen.	
(Al-Qareer et al. 2004)	Sheep	Periodontal	Conventional access flap, apically repositioned flap, distal wedge procedure, coronally advanced flap, gingivectomy (including the sutures: continuous, periosteal, interrupted and sling).	Shows suitability of various areas in sheep mandibles for different periodontal surgical methods and thereby why it might be a feasible training model for demonstration and exercise of various periodontal surgical techniques	Dentition, periodontal probing depths and occurrence of periodontal pathology
(Acar et al. 2010)	Sheep	Oral	Endoscopic sinus surgery	The residents' performance after practicing surgery on the sheep cadaver model was evaluated and at the end of the course the authors reported significant improvement of the residents' surgical skills and use of surgical equipments. Additionally, they registered a significantly shortening of operation time	No specific features described
(Ghiabi and Taylor 2010)	Animal models in general	-	-	-	-
(Stelzle and Benner 2010)	Pig	Oral	Direct sinus floor elevation	No teaching outcome described	Thickness and structure of the maxillary sinus and the osseous microstructure of the lateral sinus wall.
(López-Niño et al. 2012)	Sheep	Oral	Sinus floor elevation	Comparison of key features (TLWMS and TSM) between animal model and the human standard in order to show the potential use for training sinus floor elevation techniques within a teaching environment	Thickness of the lateral wall of maxillary sinus (TLWMS) , thickness of the Schneiderian membrane (TSM)

(Larsen et al. 2013)	Pig and Sheep	Periodontal	Gingivectomy, modified access flap, coronally advanced flap, apically repositioned flap, papilla preservation flap, GTR with membranes and distal wedge procedure	A table shows suitability of various areas in the pig model and the sheep model for different periodontal surgical methods. The procedures are based on a practical course for the undergraduates at the University of Tromsø	Dentition, facial bones, macroanatomy, periodontal probing depths, average width of the gingiva and occurrence of periodontal pathology
(Zangrando et al. 2014)	Pig	Periodontal	Gingivectomy, distal wedge procedure, frenectomy, internal bevel incision, total/ partial flap, furcation access, gingival grafts and suture techniques.	Students reported that the laboratory was fundamental regarding the reproducibility of surgical techniques, reliability for patient's treatment and suture management.	No specific features described

This systematic review attempted to describe which animal models have been used for teaching/ training periodontal and oral surgical methods, as well as the teaching outcome. Animal models contribute to the dental education programs at many institutions, and in North America the cadaver used in teaching preclinical components count for about 45 % (Ghiabi and Taylor 2010). The most commonly basic surgical procedures that are taught by the respondents using an animal cadaver model are conventional flaps, periodontal plastic procedures and suturing, all used in about 40 % of the educational programs (Ghiabi and Taylor 2010).

Evaluations of the effect of introducing the cadaver model system into both the undergraduate and graduate teaching programs have been described by several studies. The knowledge of the students who attended a pre-clinical laboratory teaching course has been compared to students at the same institute who only received lectures and observation of the clinical instructors. Acar et al. (2010) developed an animal cadaver model (sheep) which would give the residents the opportunity to learn endoscopic sinus surgery. The residents' performance after practicing surgery on the sheep cadaver model was evaluated by the authors with the help of CT-scans. At the end of the course the authors reported significant improvement of the residents' surgical skills and use of surgical equipments. Additionally, they registered a significantly shortening of operation time.

Surgical improvement in both periodontal and oral surgery has also been described by both Cumming and Glavind (1972) and Zangrando et al. (2014). In both studies the students

received a questionnaire to evaluate their understanding of the theoretical subject, confidence in performing the surgical procedures and the subjective feeling of surgical improvement. In the study performed by Cumming and Glavind (1972), 64 % reported that the laboratory was helpful regarding understanding theory and 58 % reported they received confidence to perform surgery with minimum supervision. In the study designed by Zangrando et al. (2014), 64 % of students reported that the laboratory was fundamental regarding the reproducibility of surgical techniques, 72 % reported that the reliability for patient's treatment was fundamental and 80 % stated that the laboratory was fundamental regarding suture management. Clinical instructors not involved in the seminars assessed the students' clinical performance, and the results revealed a considerable improvement in surgery related to the pig mandible instruction as well as an improvement in surgeries indirectly related (Cumming and Glavind 1972). In the article by Bonnette and Hayward (1969) the students greatly acknowledged having had the opportunity to learn technical methods and motor skills on the pig model, and the course gave them better confidence and understanding prior to entering the oral surgery clinic.

Of the 12 selected articles seven described the pig as an animal model and four described the sheep/ lamb. Other animals used in experimental studies include rabbits, dogs, goats and mini-pigs (Stelzle and Benner 2010).

The fresh pig head specimen as a teaching model is widely used and a common model in periodontal surgery (Cumming and Glavind 1972; Larsen et al. 2013; Weissman 1988; Zangrando et al. 2014). The pig as a teaching model is also described in terms of oral surgery (Bonnette 1969; Stacy 1967; Stelzle and Benner 2010). Procedures mentioned and described for this model are listed in **Table 1.** The pig is shown to be suitable as a teaching model for several purposes; it provides, among other things, anatomical similarities to human, such as size and shape of the teeth and gingival tissue (Zangrando et al. 2014).

The sheep/ lamb is not as commonly used as a teaching model in periodontal surgery compared to the pig. However, some studies have used the sheep in order to show its suitability as a teaching model (Al-Qareer et al. 2004; Larsen et al. 2013). One of the reasons includes that the pig is not always available due to religious consideration (Al-Qareer et al. 2004). The sheep model has also been used in terms of oral surgery (Acar et al. 2010; López-Niño et al. 2012). Procedures mentioned and described in both oral and periodontal surgery are listed in **Table 1.**

In the study by Larsen et al. (2013) a comparison was made of the sheep model and the pig model as of periodontal surgery. The surgical procedures were performed on both types of specimens in order to evaluate where the procedures were most suitable. Suitability tables were made for both specimens according to the periodontal surgical procedures. Most procedures could be performed in either specimen, except the papilla preservation flap which was only suitable in the sheep cadaver (Larsen et al. 2013). Other shortcomings in the pig model include that the "[…] freshly slaughtered pigs are usually not older than 8 months and present deciduous teeth only" (Al-Qareer et al. 2004). Additionally, teeth in the anterior area of the pig are small and have big spaces between them (Larsen et al. 2013). No differences in periodontal pathology was found and the possible risk for infection with the use of animal models is considered minimal (Al-Qareer et al. 2004; Larsen et al. 2013).

The use of animal models in teaching undergraduate and graduate oral and periodontal curriculum has been proven suitable. Advantages of both the sheep and the pig models includes: easily obtainable (Acar et al. 2010; Al-Qareer et al. 2004; Moore et al. 1965; Weissman 1988), inexpensive (Acar et al. 2010; Moore et al. 1965; Zangrando et al. 2014), absence of bleeding and salivation (Cumming and Glavind 1972; Zangrando et al. 2014), and similarities to the human in terms of tissue texture (Weissman 1988) and anatomical features (Acar et al. 2010; Zangrando et al. 2014).

In conclusion, the benefit of using a cadaver model in the teaching of periodontal and oral surgery is evident, and students usually express great interest in the opportunity. Both pig and sheep have certain advantages that make them suitable and valuable as teaching models used in pre-clinical laboratory for undergraduates and graduates.

2.2 Anatomy of sheep jaws

2.2.1 Sheep dentition

Like humans, sheep are diphyodont; they have two sets of teeth during their lifespan. Another similarity to human is that the sheep's deciduous dentition consists of 20 teeth and their permanent dentition consists of 32 teeth (Weinreb and Sharav 1964). While in humans there are upper incisors and canines, in sheep these upper teeth are missing. Instead, a very broad, thick pad of connective tissue, called the upper dental pad, is present. This dental pad

occludes with the lower eight incisors, and the sheep uses the dental pad mainly for gathering grass and other plant materials (Nickel et al. 1979).

In all mammals, the teeth are composed of enamel, dentine and cementum, and the teeth are attached to the alveolar bone with periodontal ligaments (Nickel et al. 1979). While humans get their first deciduous teeth mainly after birth, the sheep is born with deciduous teeth. The teeth are already grown into the occlusal plane and are covered with a thin layer of gingival tissue that will disappear a few days to a few weeks after birth (Hatt 1967). The deciduous teeth consist of incisors and premolars. The lower canines are incorporated into the row of incisors, and is called the fourth incisor (Nickel et al. 1979). Sheep have a total of eight incisors, known as central, first intermediate, second intermediate and corner incisors (Nickel et al. 1979). The incisors and premolars will all be replaced by permanent teeth. The human deciduous premolars are called milk molars, while the sheep's premolars are called milk premolars (Nickel et al. 1979). The sheep has consequently no deciduous molars, only permanent molars **(Table 2)**.

Table 2: Time of eruption and replacement of deciduous and permanent teeth – sheep (Nickel et al. 1979)

Teeth	Time of Eruption*	Teeth	Time of Replacement*
Di_1	Before birth – up to 8 days	I_1	12-18 months
Di_2	Before birth	I_2	21-24 months
Di_3	Before birth	I_3	27-36 months
Di_4	Birth – up to 8 days	I_4	36-48 months
$Dp\frac{2}{2}$	Before birth – up to 4 weeks	$p\frac{3}{3}$	21-24 months
$Dp\frac{3}{3}$	Before birth – up to 4 weeks	$p\frac{3}{3}$	21-24 months
$Dp\frac{4}{4}$	Before birth – up to 4 weeks	$p\frac{4}{4}$	21-24 months
$M\frac{1}{1}$	3 months		
$M\frac{2}{2}$	9 months		
$M\frac{3}{3}$	18 months		

*** The lower figures are for early-maturing breeds, the higher figures for late-maturing breeds.**

The replacement of deciduous teeth happens gradually and in a defined order (**Table 2**). In addition to all the permanent teeth that will replace the deciduous teeth, three molars posterior to the deciduous premolars erupt approximately at three, nine and eighteen months after birth (**Table 2**) (Nickel et al. 1979). However, the eruption time varies between different breeds (Weinreb and Sharav 1964).

An important difference between the human teeth and the sheep teeth is that, while human teeth seizes to erupt when they come into occlusion, the sheep teeth continue to grow throughout life as the teeth wear down (Barnicoat 1957). That is perhaps the reason why premolars and molars of the sheep have very long, massive roots and short coronal parts.

The sheep specimens we used in the present study were born between April 20th and May 10th, and were approximately 4-5 months old when slaughtered.

2.2.2 Sinus system in sheep

Like humans, the sheep have paranasal sinuses which are air-filled spaces lined with mucosa. The paranasal sinuses of the sheep consist of the maxillary sinus, the frontal sinus, the palatine sinus, the sphenoid sinus, the lacrimal sinus, the dorsal conchal sinus, the ventral conchal sinus and the ethmoid cellules. The lacrimal, dorsal conchal, ventral conchal and ethmoid sinuses are only present in pigs, horses and ruminants. The function of the sinuses is somewhat ambiguous (Nickel et al. 1979).

The sinuses that are of most relevance to this study are the maxillary sinus and the palatine sinus which are located above the molars. In sheep the maxillary sinus is embedded in the maxillary bone, zygomatic bone and in the bulla of the lacrimal bones (Nickel et al. 1979). The maxillary sinus is divided into two compartments by the infraorbital canal, called the lateral and medial compartments. The lateral and medial compartments are connected to, respectively, the lacrimal bulla and palatine sinus (Mansour 2017).

The palatine sinus is comprised of the horizontal lamina of the palatine bone and the palatine process of the maxilla. The osseous roof of the palatine sinus is incomplete; consequently the palatine sinus is separated from the nasal cavity only by a double layer of mucosa (Nickel et al. 1979). The roots of the sheep molars may project into the maxillary sinus (Mansour 2017).

2.2.3 Periodontitis in sheep

Spontaneous periodontitis in sheep occurs in two different forms. One of the forms affects primarily the incisors, while the other form affects both incisors and molars but is largely confined to the latter (Hitchin and Walker-Love 1959).

"Broken mouth," also called premature incisor loss, is the type of periodontitis that affects mainly the incisors of the sheep. Broken mouth occurs in young sheep while the permanent incisors are still erupting. It is a severe form of periodontitis and most of the incisors are already missing by the age of 4.5 years old. The etiology of broken mouth is still uncertain, but factors like genetic effects, farm environment and infection from plaque-forming bacteria are all considered likely to contribute to broken-mouth (Hitchin and Walker-Love 1959).

2.3 Objectives

In the dental educational program at UiT, The Arctic University of Norway, the undergraduates have several lectures on how to perform surgical procedures in both periodontal subjects and general oral surgery subjects. However, the students have minimal amount of clinical experience prior to performing these surgical procedures for the first time on humans. The only pre-clinical practice the students get to perform prior to surgery includes; suturing techniques on rubber dam and foam, in addition to tooth extractions on mannequins.

The systematic review revealed that animal models as a teaching method improve surgical skills and confidence among both undergraduates and graduates before performing surgery on patients. The pig model is one of the most studied and used specimen in oral and periodontal surgical training, however the sheep model is proven equally suitable through several studies.

Both Al-Qareer et al. (2004) and Larsen et al. (2013) only focused on demonstrating the suitability of performing periodontal surgical procedures in the sheep mandible. With that in mind the aim of this study is to demonstrate how the sheep maxilla could be equally suitable in demonstrating and teaching basic surgical procedures in both periodontal and oral surgery. In that way, the whole sheep head could be utilized in training and teaching surgical procedures. The surgical procedures chosen to be performed in this study will complement the surgical procedures already performed by Al-Qareer et al. (2004) and Larsen et al. (2013), to

further demonstrate the sheep model's versatility. This will result in a more cost-effective teaching model.

Furthermore, a proposal is made for organization of practical courses in both periodontics and oral surgery to facilitate implementation of these courses in the educational program for dental undergraduates. This would hopefully make the undergraduates more confident and skilled prior to performing surgical procedures on patients for the first time.

3 Material and methods

3.1 The sheep specimens

IKO (Department of Clinical Dentistry) buys sheep heads from a local butcher, which are used in this study. Earlier, when looking for ways to buy the sheep specimen, IKO contacted a local distributor. The local distributor wanted 150 NOK per head for delivering the sheep heads to the University. IKO later got in contact with the local butcher used in this study, and paid 20 NOK per head.

Previous years the butcher would separate the mandibula and the maxilla prior to selling, however IKO experienced that the mandibula was not separated in a satisfying manner. Therefore, IKO ordered complete sheep heads in order to do the separation with a satisfying result. The sheep specimens arrive in frozen blocks of approximately 10 heads per block. They are thawed to be separated from each other, and then packaged into separated bags before reinserted in the freezer. The freezer holds a temperature of -20 °C.

The dissection laboratory at the MH-building is used to prepare and perform surgery on the sheep specimens. In that way, any contamination risk is avoided and safe disposal of the cadaver after the surgical sessions is accomplished. The equipments used during the surgical course are instruments UTK (University Dental Clinic) has donated with the sole purpose of using on sheep. The equipments are washed, sterilized and packaged separately from other equipments used at UTK, with no risk of contamination.

A contact person at the dissection laboratory thaws the sheep heads prior to the surgical sessions. It is important that the sheep heads are completely thawed to manage separating the jaws. The sheep specimens are thawed in cooling room (+4 °C) for 3 days, in that way the thawing process is controlled and the sheep specimens retain water. The cooling room is also

used to avoid desiccation of the heads and any smell. If the heads are thawed in room temperature it would approximately take 24 hours, and the specimens would give up water.

3.2 Equipment list

Summary of the surgical equipment used in the surgeries of the sheep's maxilla are listed in **Table 3.**

Table 3: The surgical tray used in the surgeries of the sheep's maxilla*	
Instruments:	***Used in conjunction with:***
Scalpel handle Hu-Friedy 10-130-07K	*Oral surgery and periodontal surgery*
Suture needle and thread Ethicon, Ethilon*II, polyamide 6, 5-0, 45 cm	*Oral surgery and periodontal surgery*
Mathieu needle holder Hu-Friedy NH5076	*Oral surgery and periodontal surgery*
Adson tissue pliers Hu-Friedy TP5041	*Oral surgery and periodontal surgery*
Micromotor PROLAB Bien Air	*Oral surgery and periodontal surgery*
Plandent PB-084-11B1 Kirurgisk saks rett	*Oral surgery and periodontal surgery*
Periosteal elevator Hu-Friedy P24GSP	*Oral surgery and periodontal surgery*
Scalpel blades Swann-Morton no.15 and no.10	*Oral surgery and periodontal surgery*
Burs: • Meisinger HM236.106.014 rosenbor hardmetall, ekstra lang • Komet H166.204.021 Hardmetallbor benfreser Lindeman	*Oral surgery and periodontal surgery*
Elevator: Martin Germany (42 505 01)	*Oral surgery*
Forceps: Martin Solingen (M2022)	*Oral surgery*
Self-Aspirating Cartridge Syringe - Aspiject ronvig Denmark	*Oral surgery*
Syntette LM-Dental LM 215/16	*Periodontal surgery*
Regular scissors	*Preparation of sheep head*
Scalpel blades: Swann-Morton no. 22	*Preparation of sheep head*
Scalpel handle: Swanns Morton (4)	*Preparation of sheep head*
***Please note that there might be differences in companies and ordering numbers.**	

3.3 Surgical procedures in sheep maxilla

Table 4: Surgical procedures performed in sheep maxilla		
Procedures performed:	**Specification:**	**Subject:**
Extraction of tooth	Use of both elevator and extraction forceps	*Oral surgery*
Surgical removal of impacted tooth		*Oral surgery*
Procedure following sinus perforation	Performed following surgical removal of impacted tooth	*Oral surgery*
Biopsy	Excisional biopsy	*Oral surgery*
Different sutures	Knots which stabilizes sutures Mattress suture Simple interrupted suture Sling suture and GTR membrane Periosteal suture	*Oral surgery*
Tunnel preparation		*Periodontal surgery*
Free gingival graft		*Periodontal surgery*
Hemisection		*Periodontal surgery*

3.4 Photographic documentation

The camera used in this study is Canon EOS 500D with Canon Zoom Lens EF-S 18-135 mm and Sigma EM-140 DG Macro flash unit.
Camera settings used are shutter speed: 1/125 seconds, aperture: F22 and ISO: 200.

The pictures were edited using PhotoScape X PRO, and changes made include: rotations, cropping, adjustments in brightness, levels, contrast, sharpness, clarity, size-adjustments and deepening of each individual picture. Each adjustment was to make them more or less standardized. The pictures were then numbered and organized into a step-by-step collage for each individual procedure, including preparation of the sheep specimen.

4 Results

4.1 Laboratory findings of sheep dentition

The morphology of the human and sheep teeth is very different. The premolars, apart from the first premolar, and molars of the sheep vary greatly compared to premolars and molars in humans. While human molars comprise of mainly two to three separated roots depending on the jaws, the sheep molars have one massive and compact root. This root morphology extends to the coronal part of the tooth.

Another extensive difference between human and sheep molars is that the sheep molars consist of what looks like two partially merged crowns with one common root (**Fig. 2**). From a buccal and lingual view, it is easy to believe that the molar is two separated molars, when actually being one massive molar.

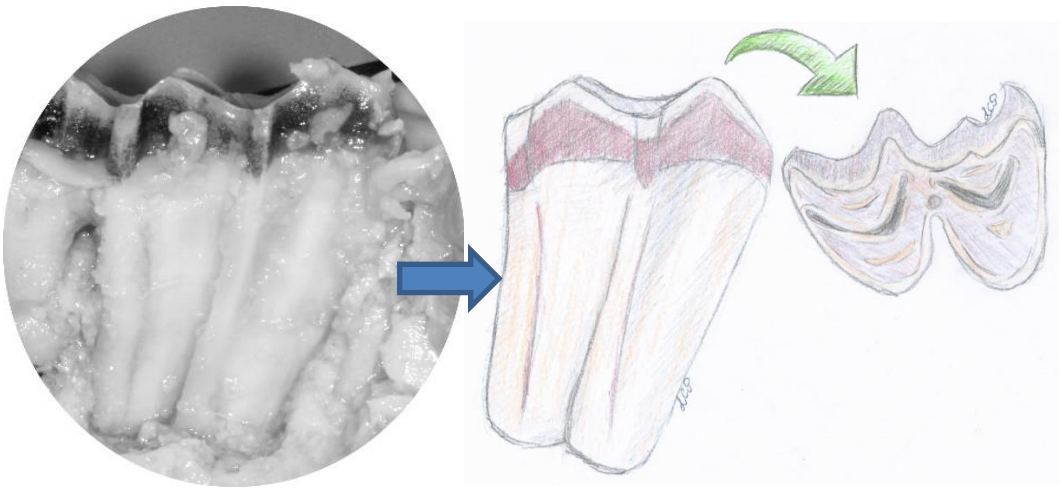


Fig. 2. Morphology of permanent molar in sheep. *An embedded first permanent molar in the sheep maxilla, where the buccal alveolar bone is removed to show the morphology of the tooth. A sketch of the first pemanent molar shows how the tooth consists of a massive root that looks like two merged roots. From occlusial view the crown looks especially like two separated crowns merged together.*

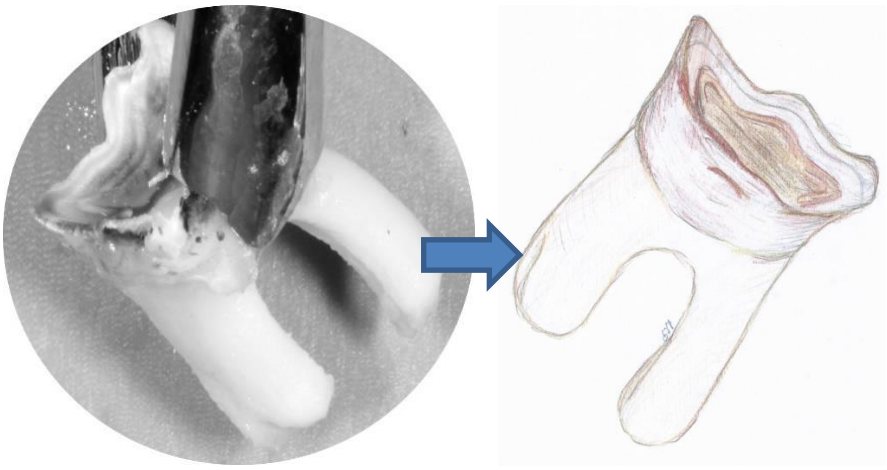


Fig. 3. Morphology of decidious premolar in sheep. *An extracted first deciduous premolar and a sketch showing the morphology of the first deciduous premolar. The pictures show two separated roots similar to a mandibular human molar.*

The first deciduous premolar in the sheep maxilla has some similarities to a human tooth (**Fig. 3**). From occlusal view, little looks like a human tooth. However, upon extraction, there is a small well-defined coronal part and two separated roots just like a small, lower human molar.

Based on **Table 2**, the sheep specimens used in the study, have mixed dentition with deciduous premolars and fully erupted first molars. The second molars are either partially erupted in some of the heads or not erupted at all in others. All the deciduous teeth are still in place, and have not yet been replaced.

4.2 The procedures step by step

In order to implement and facilitate the use of the animal model in pre-clinical courses in periodontal and oral surgery; a detailed description of each procedure is made along with figures.

4.2.1 Preparation of sheep head

Below are figures showing step-by-step of how to separate the jaws and prepare the sheep maxilla for surgery. It was found that using a scalpel with blade size 22, a pair of scissors and muscle strength is sufficient.

Fig. 4, step-by-step separation of sheep head; *(A) The cheeks are cut and opened all the way back to ramus of the mandible with a scalpel. (B) The jaws are then opened by pulling the mandible away from the maxilla. (C) The muscles in the back of the throat need to be cut. It is important to cut all the muscles that keep the mandible attached to the rest of the sheep head, in order to separate the two parts. (D) The two jaws are easily pulled apart, and excessive soft tissue and muscles are removed either by scalpel or scissor. (E-F) The mandible and maxilla are cleaned and ready for surgery.*

4.2.2 Extraction of tooth with elevator and forceps

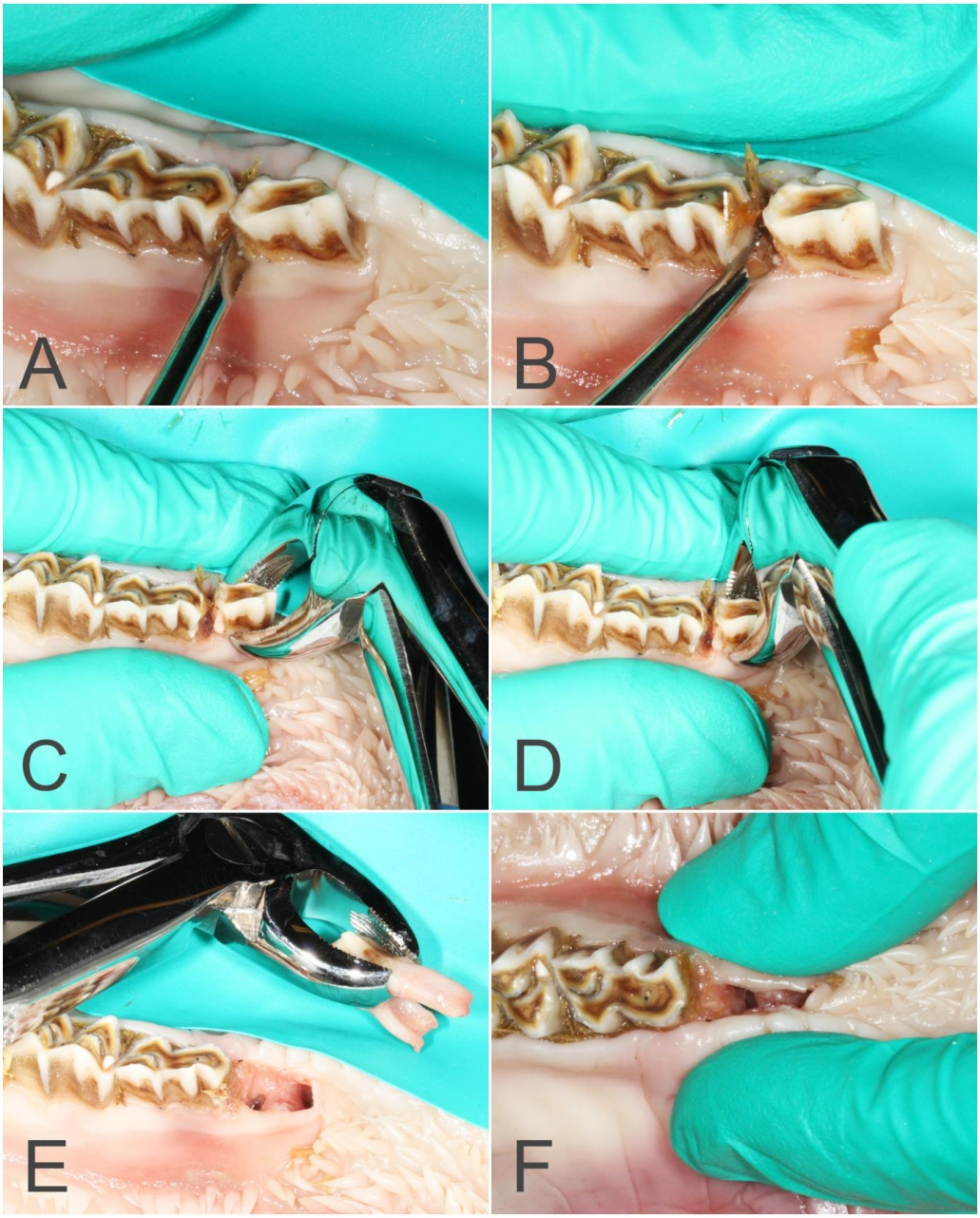


Fig. 5, Extraction of tooth with elevator and forceps; *(A) The elevator is placed in the interdental space. The soft tissue is loosen and the periodontium torn with a sharp instrument such as a carver or probe. This is to ensure that the patient is sufficiently anesthetized and to allow the elevator to be positioned more apically. (B) The elevator is turned so that the portion of the blade is turned toward the tooth being extracted (anti-clockwise in this case). Strong, slow, forceful turning of the handle moves the tooth in an anterior direction. A wider elevator could be preferred when the tooth becomes luxated. (C) The forceps is placed onto the tooth with apical pressure. Two fingers are placed buccally and lingually to the tooth to ensure that no bone fractures occur. (D) The tooth is luxated by moving the tooth in a buccal-lingual direction with a slow, steady force to expand the alveolar socket (the force should be held for several seconds to allow the bone time to expand). (E) Once the tooth is completely luxated, it is removed from its socket by a slight tractional force, usually directed buccally. The extracted tooth should always be examined for any indications of root fracture. (F) The alveolar socket should also be examined for loose bone or root fragments and to ensure good hemostasis. The soft tissue around the open alveolar socket should be compressed for better healing.*

4.2.3 Surgical removal of impacted tooth with a sinus perforation

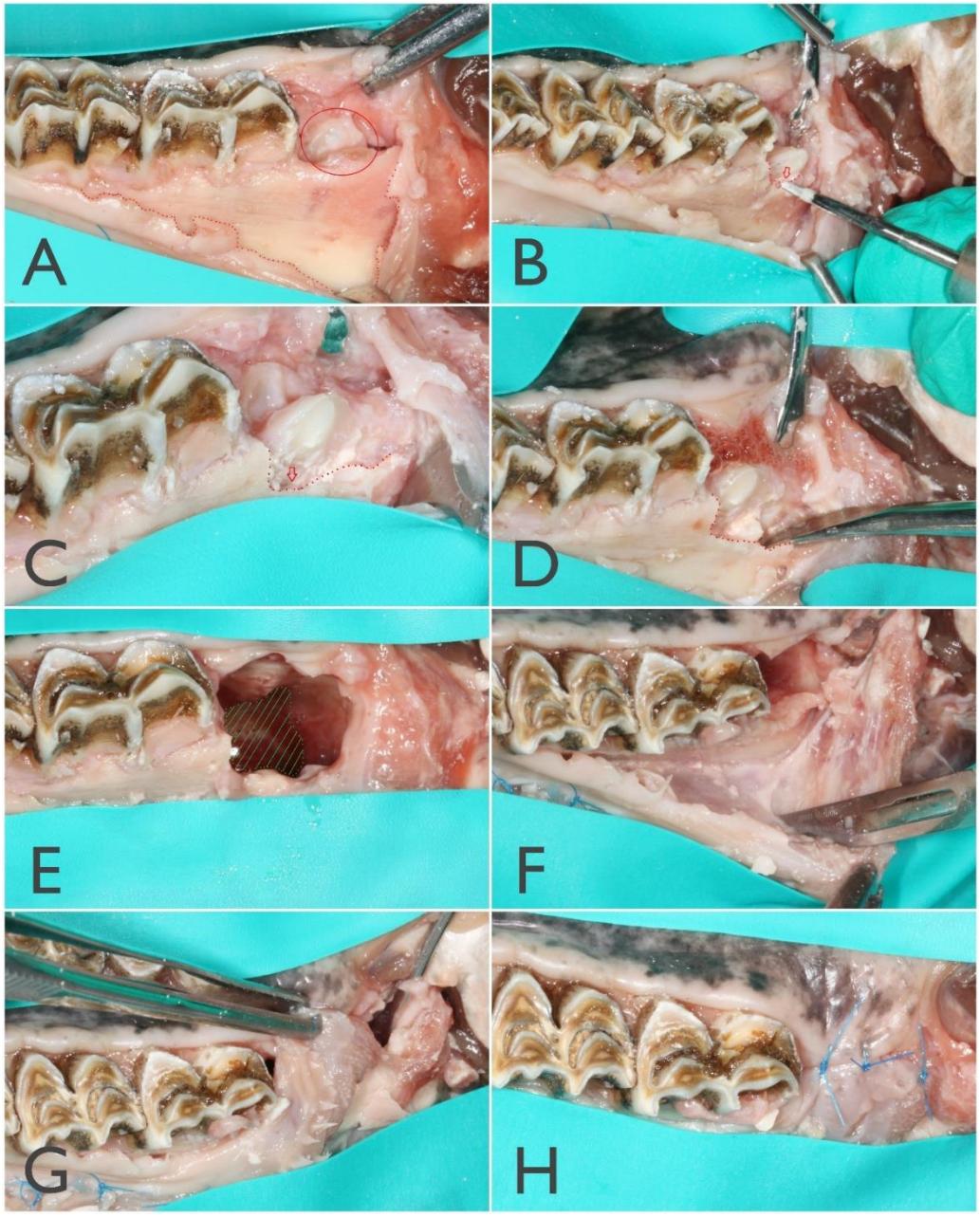


Fig. 6, Surgical removal of impacted tooth with a sinus perforation; *(A) Three-cornered flap: An intracrevicular incision is made from the mesial papilla of the maxillary first molar to the distobuccal line angle of the second molar, and a releasing incision is made in a distobuccally direction posteriorly to the impacted tooth. The mucoperiosteal flap is retracted apically with a periosteal elevator, and the partially impacted tooth appears (circled). (B-C) By using a micro motor and a large round bur, the cortical bone occlusially, buccally and distally to the impacted tooth is removed all the way down to the cervical line of the impacted tooth. Bone tissue should not be removed lingually! (D) The partially impacted tooth is then elevated and removed with a small, straight elevator. A bone file is used to smooth any sharp, uneven edges of the surrounding bone tissue. Vigorous irrigation with sterile saline is necessary to remove bone fragments and debris from the wound. (E) In cases where a considerable sinus perforation occurs after removing the impacted tooth, a flap procedure to close the alveolar socket from the oral cavity is needed. (F) In order to reposition the flap over the alveolar socket without any tension of the gingiva across the extraction site, the periosteum is being incised in the vestibule. (G-H) The flap is passively repositioned across the extraction site, and fixated with simple interrupted sutures. Notice that the flap margins extend well beyond the extraction site before suturing.*

4.2.4 Biopsy

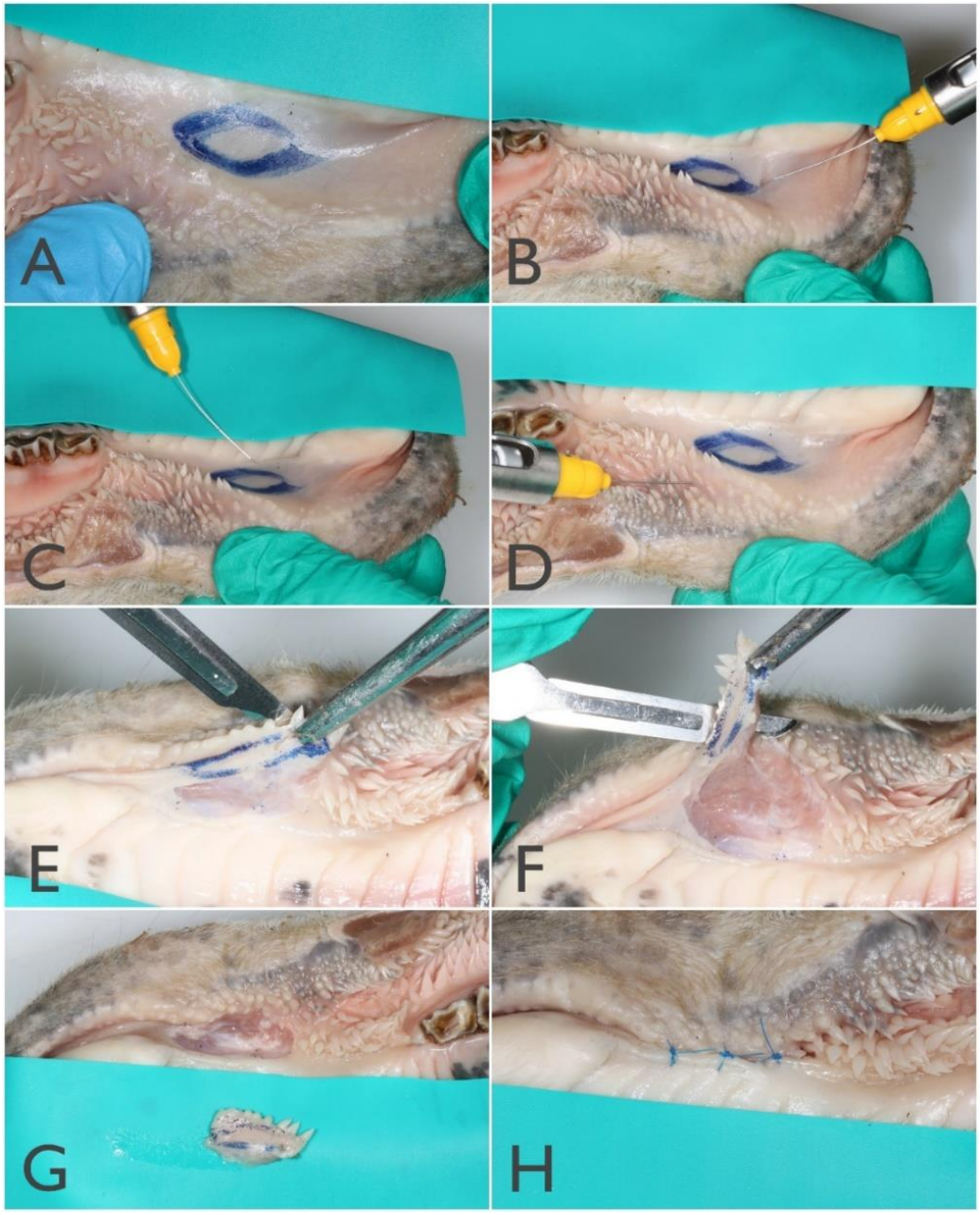


Fig. 7, Biopsy; *(A) The outline for the excisional biopsy is drawn in a boat-shape around the lesion, ensuring presence of healthy tissue at the margins. (B – D) Anesthesia is then placed in various directions around this outline. (E – F) A tissue plier is used to ensure stability while using the scalpel. (G) Notice, the biopsy should go deep enough to remove any unhealthy tissue. (H) At the end, regular sutures are placed to close the wound.*

4.2.5 Different sutures

4.2.5.1 Knots that stabilizes sutures

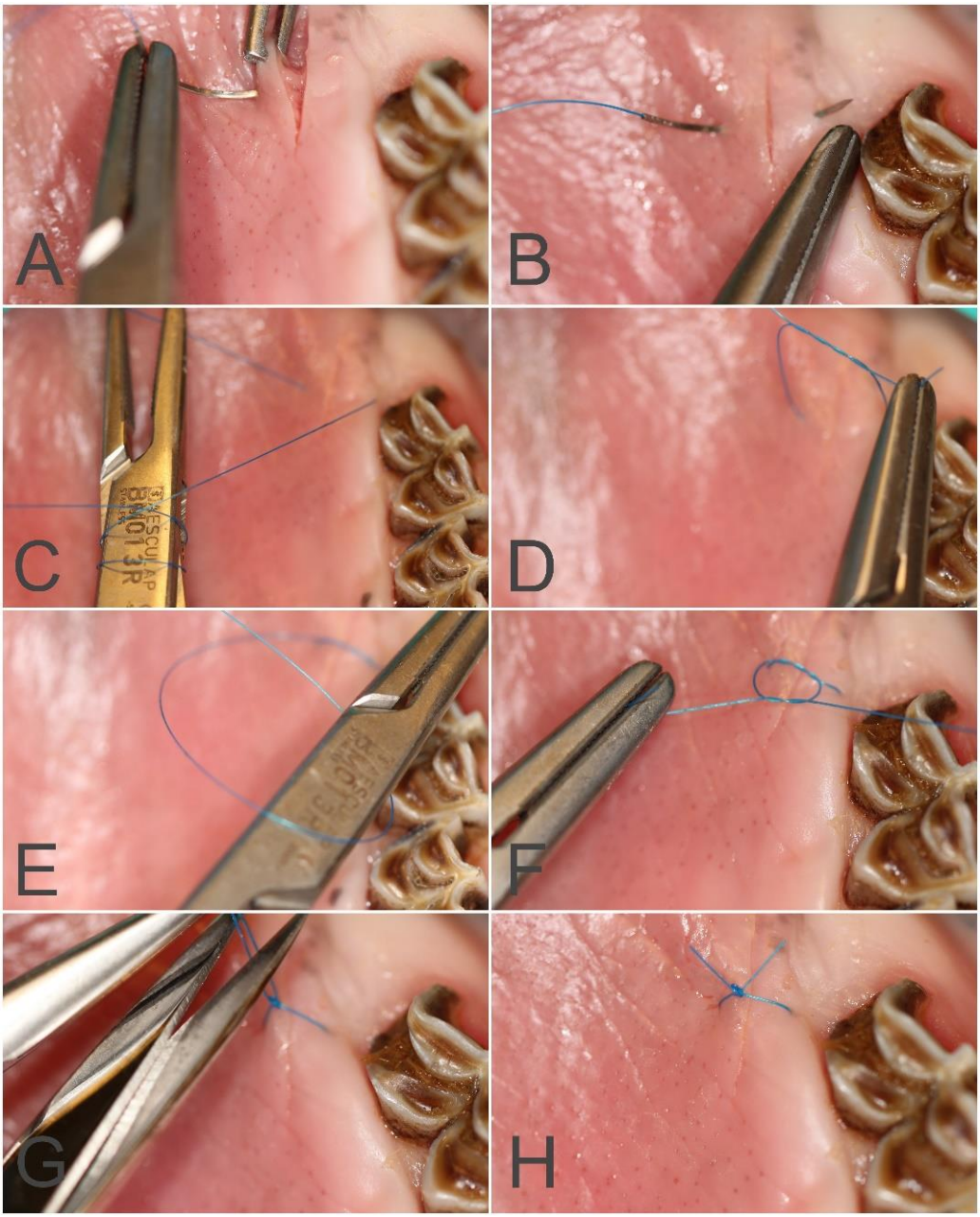


Fig. 8, Simple interrupted suture; *Interrupted suture showing a surgeon's knot and a safety knot: (A) A tissue-plier is used to ensure stability of the wound during tissue perforation. (A – B) The suture needle is grasped with the needle holder, and the needle is entered through the wound some distance from the margin of the mobile tissue and exited at the same distance on the opposite side. Notice, a small portion of suture is left on the point of insertion. (C) The suture is initially wrapped twice around the needle holder (clockwise) and the short portion of suture is then grabbed. (D) The first loop is placed over the wound and tightened (double knot/ surgeon's knot). (E) Then, a second knot (safety knot) is created by a single wrap of the suture in opposite direction (counterclockwise). (F – G) Excess thread is removed after tightening, (H) leaving two small ends above the knot.*

4.2.5.2 Mattress sutures

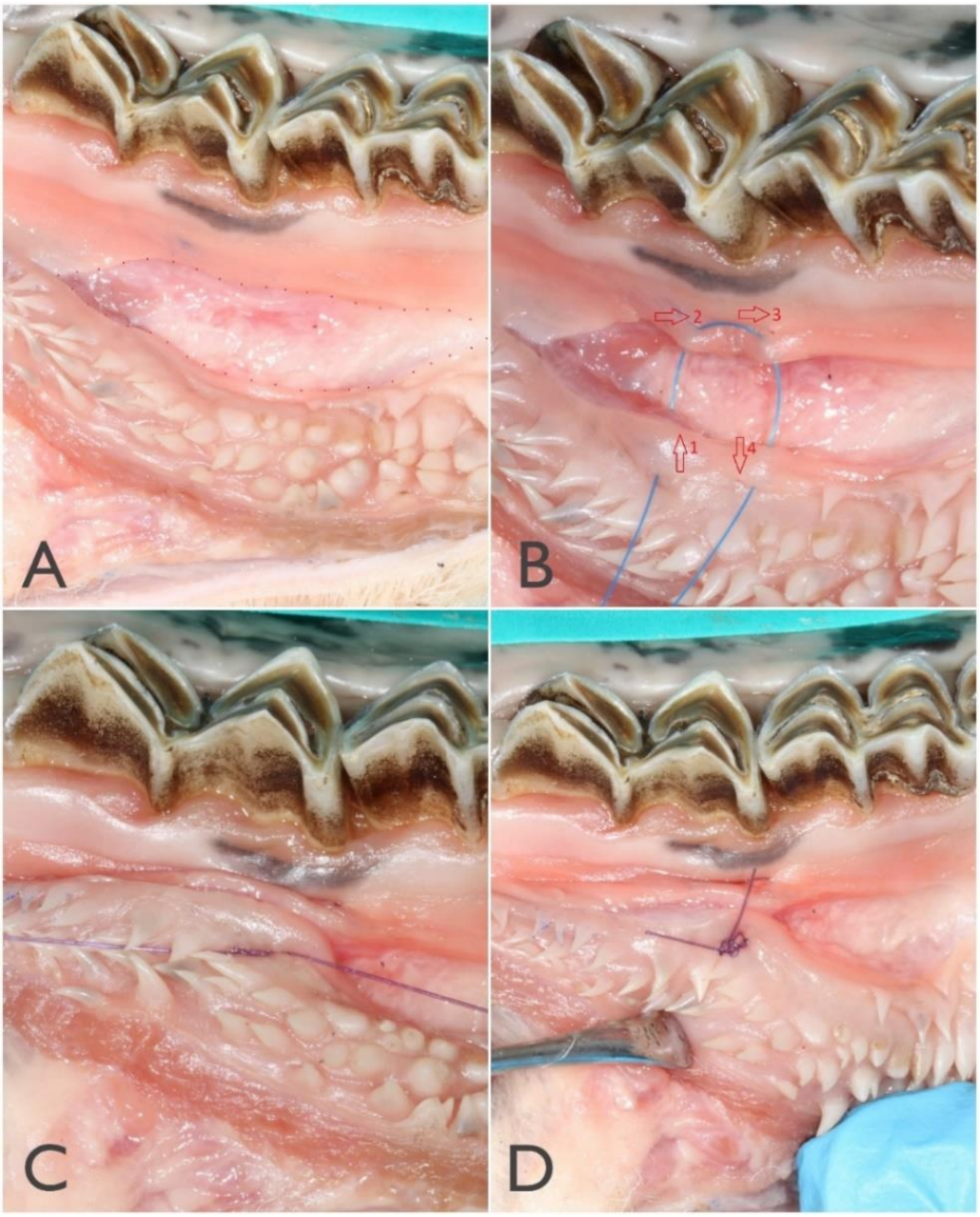


Fig. 9, Mattress suture; *Technique for horizontal interrupted suture: (A) Incision is placed. (B) The needle is inserted some distance from the edge of the wound (1) and exited through the opposite side (2). The needle is then reinserted some distance along the edge of the wound from the side of exit (3). Finally, the suture is exited at the initial side of insertion along the wound edge (4), (C – D) and a knot is tied.*

4.2.5.3 Simple interrupted suture, in interproximal space

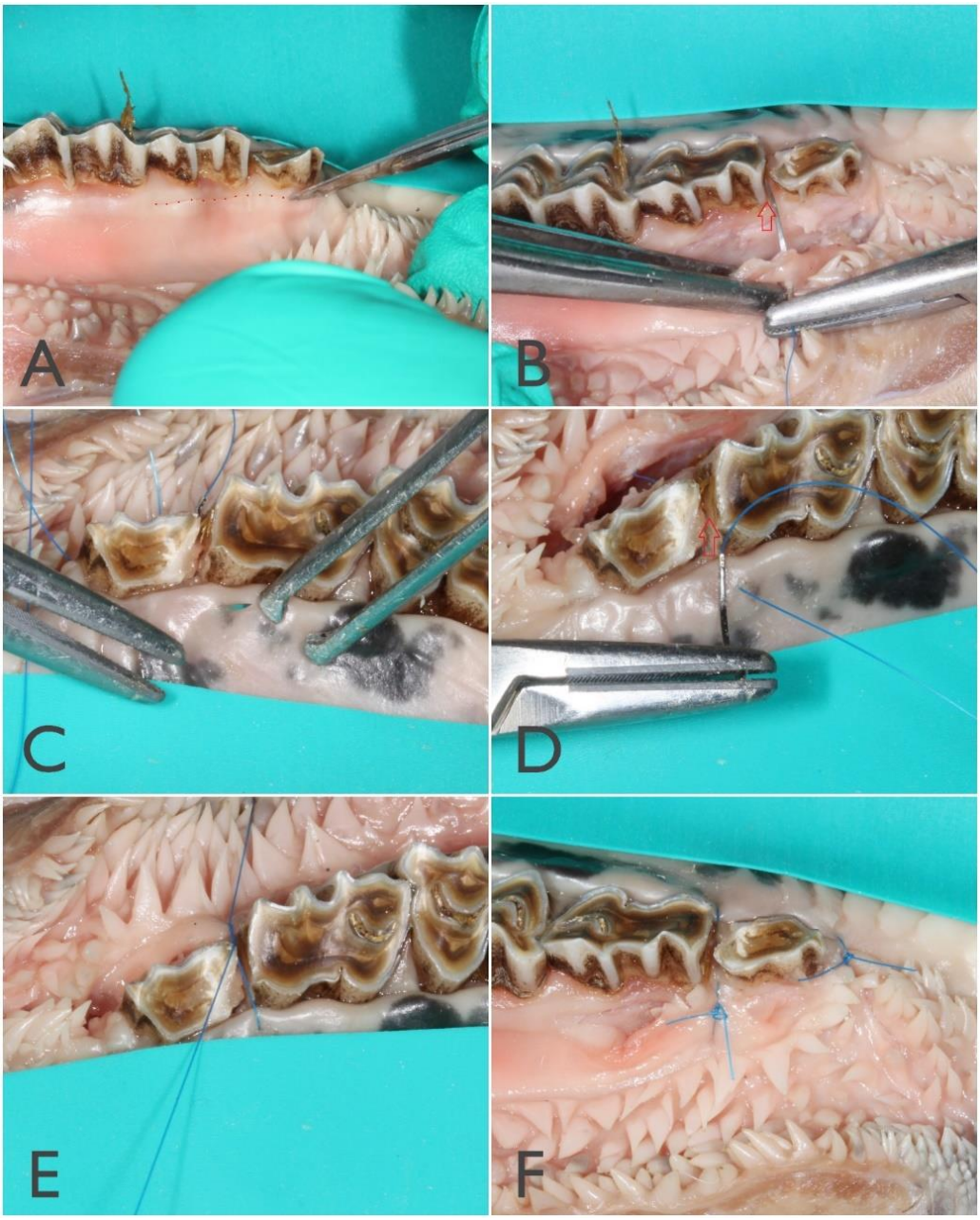


Fig. 10, Simple interrupted suture in interproximal space; *(A) Incision is placed. (B – C) The needle is inserted at some distance from the edge of the wound, exited through the interdental space, and then inserted through the mucosa on the contralateral side. (D) The needle is following backed with the non-sharp end through the interdental space. (E – F) At the end, an interrupted suture is tied.*

4.2.5.4 Sling suture with GTR-membrane

Fig. 11, Preparation of GTR-membrane; *Preparation for placement of a GTR-membrane before performing the sling suture. The suture packaging is used to simulate a membrane and the furcation involvement is simulated by removing some bone in the furcation using a periodontal curette. Beforehand, a mucoperiosteal flap is raised and the "membrane" punctured.*

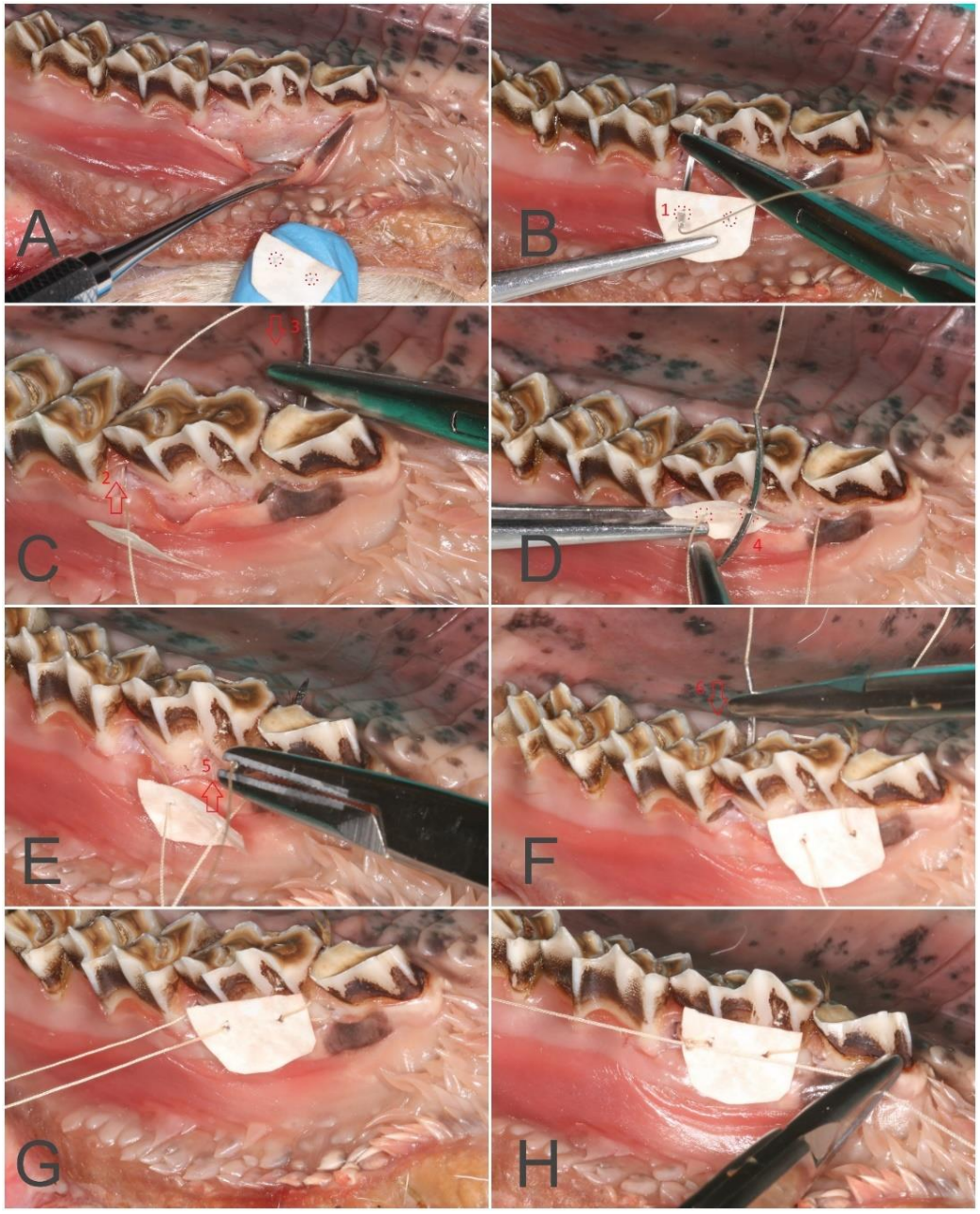


Fig. 12, Sling-suture used in placement of GTR-membrane; *Sling suture used in conjunction to placement of a simulated GTR-membrane.*

(A) The membrane is penetrated before insertion. (B – C) The needle is then penetrated through the membrane at the buccal side, and the suture is exited through the interdental space to the palatal side (1 – 2). (D) Again, exit through the interdental space to the buccal side (3). (E) At the buccal side, the needle is inserted through the second perforation in the GTR-membrane (4), (F – G) and the needle is reinserted through both interdental spaces (5 – 6) to (H) tie a knot at the first point of insertion.

Fig. 13, Finished result after placement of GTR-membrane; *After fixing the membrane in the pocket, interdental sutures are made to reposition the gingiva in the correct location.*

4.2.5.5 Periosteal sutures

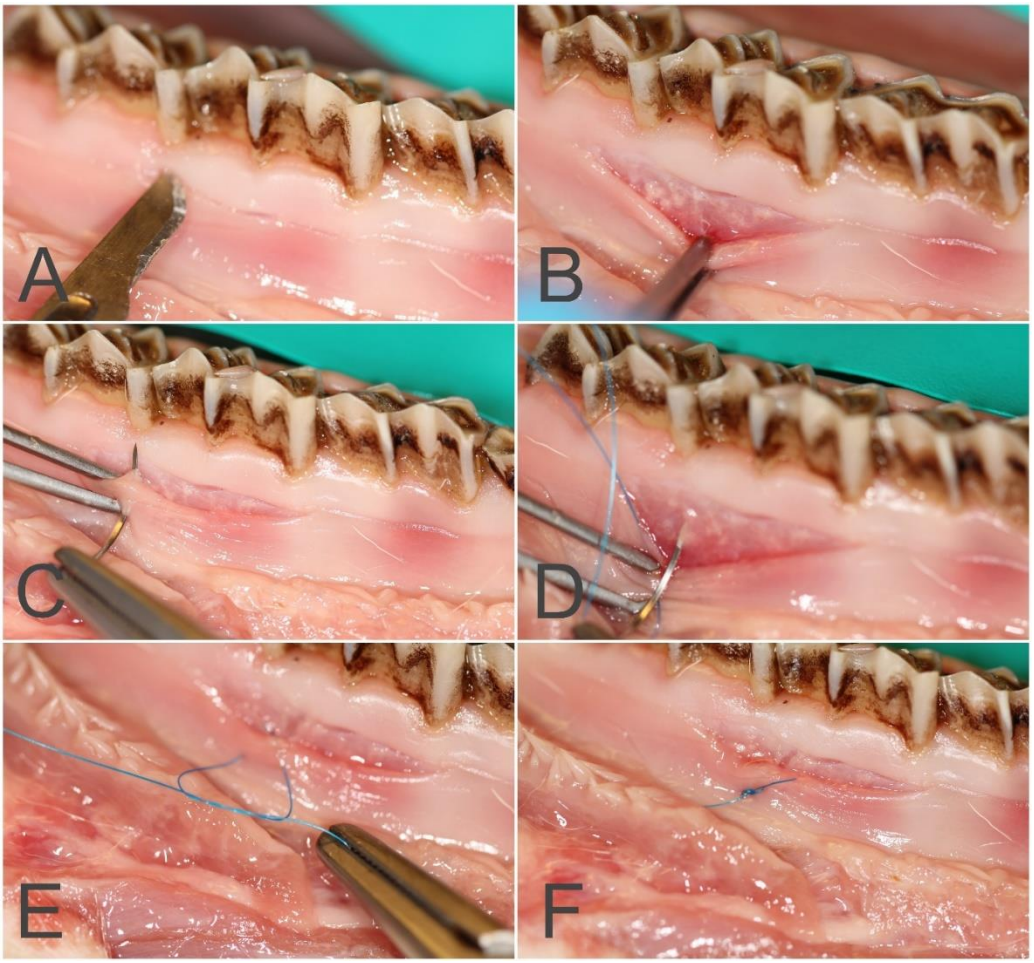


Fig. 14, Periosteal suture; *A) Incision used in the procedure "Free gingival graft". B) A tissue plier is used to hold the gingiva in the correct position. C – D) The needle is inserted some distance from the edge of the wound and into the periosteum on the underlying bone. E) The suture is reinserted in the gingiva some distance from the edge of the wound and a knot is made to secure the suture. F) Finished periosteal suture that has fixated the gingiva to the underlying bone.*

4.2.6 Tunnel preparation

Fig. 15, Tunnel preparation (I); *(A-B) A vertical releasing incision is made bucco-mesially to the treated tooth. (C) A second vertical releasing incision is made bucco-distally to the treated tooth. Notice that the releasing incision is not made in the distal papilla, but 1/3 of the adjacent tooth. (D-E) Finally an intracrevicular incision is made, and the mucoperiosteal flap is moved apically. (F-G) An intracrevicular incision is also made lingually, and no releasing incisions are needed. (H) A simulation of furcation involvement is needed in this case, and a furcation involvement degree III is created with the help of a round bur and micro motor*

Fig. 16, Tunnel preparation (II); *(I) Granulation tissue and bone fragments within the furcation area are removed with a Syntette (root planing). (J-Q) The buccal gingival flap is repositioned apically and fixated with periosteal sutures and the furcation area is exposed.*

Fig. 17, Tunnel preparation (III); *(R) The releasing incisions are sutured with interrupted sutures. (S-T) The end result is an exposed furcation area seen from both buccal and palatal side. This makes the patient able to thoroughly clean the area on a daily basis*

4.2.7 Free gingival graft

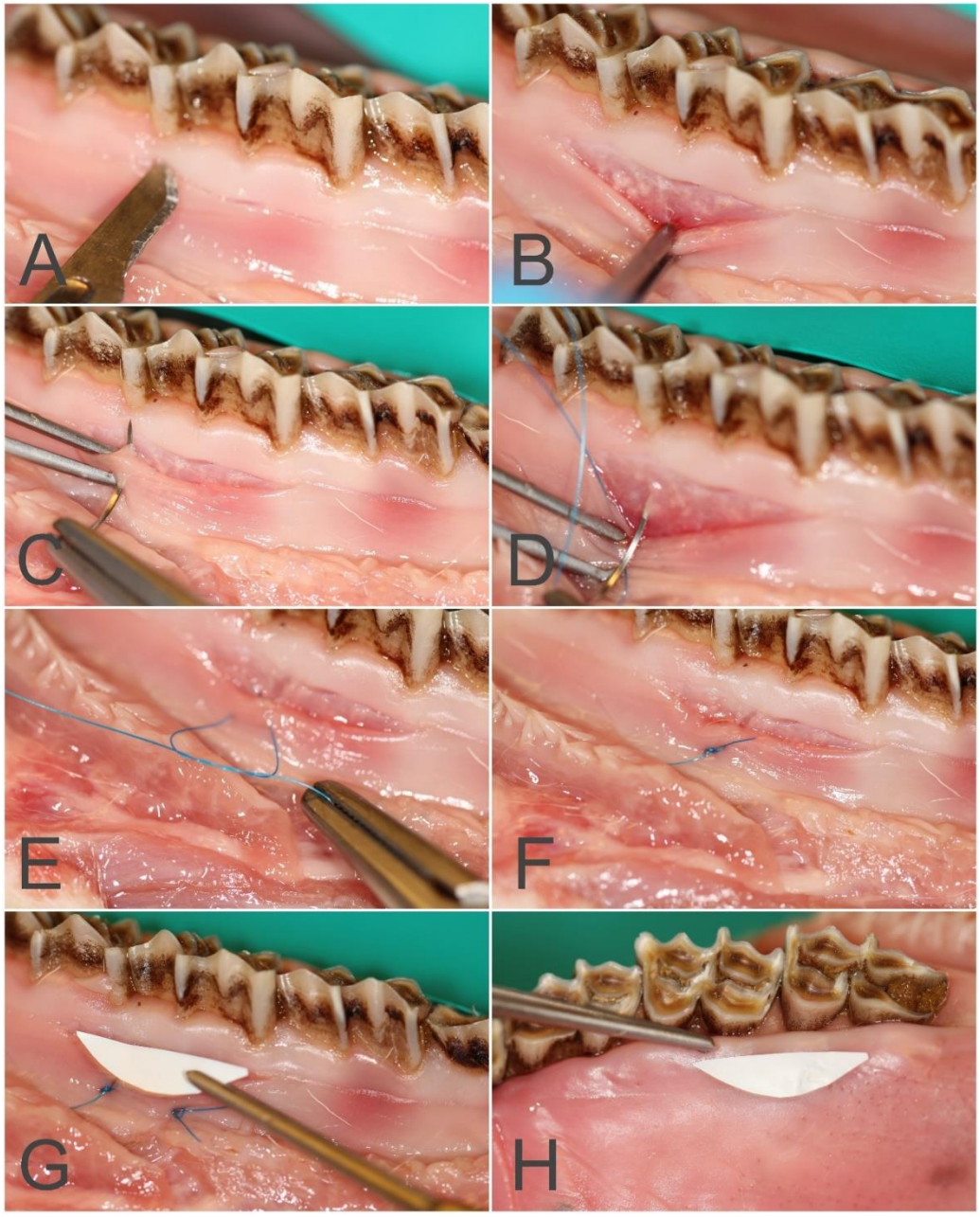


Fig. 18, Free gingival graft (I); *(A) Supraperiosteal incision at the mucogingival junction is made. (B) The attached gingiva is repositioned to make room for the graft. (C-F) The retracted gingival flap is fixated with two periosteal mattress sutures with dissolvable thread. (G) A graft template is made from the suture packaging to fit the retracted gingival flap area.*

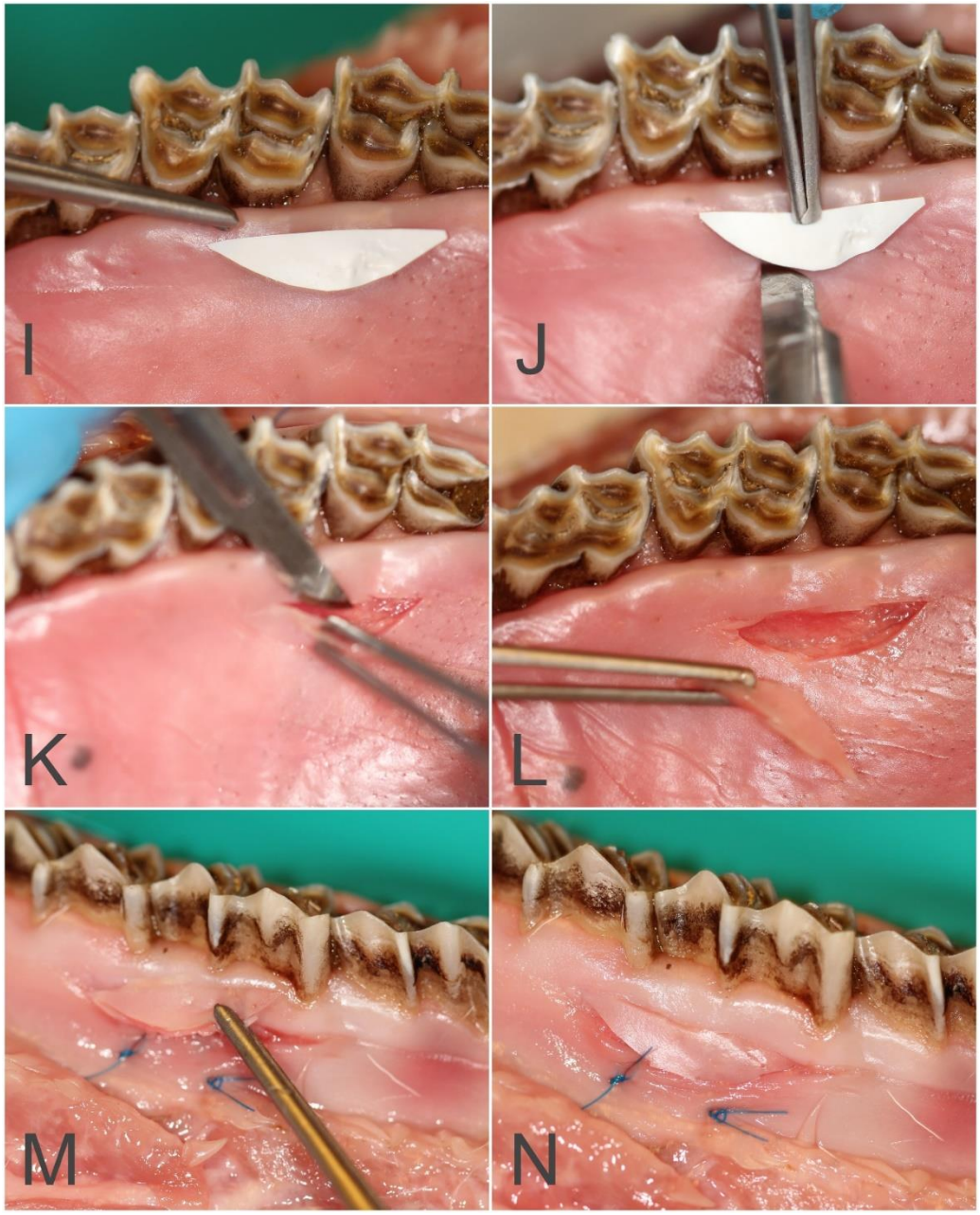


Fig. 19, Free gingival graft (II); *(H-I) The graft template is placed in a suitable area of the hard palate. (J-L) The template is used to harvest correct sized gingival graft from the palatal mucosa. (M) The gingival graft is placed and compressed with a gauze tampon for two minutes, and finally glued in two-three spots on the coronal margin with tissue glue. (N) The end-result of the free gingival graft procedure.*

4.2.8 Hemisection

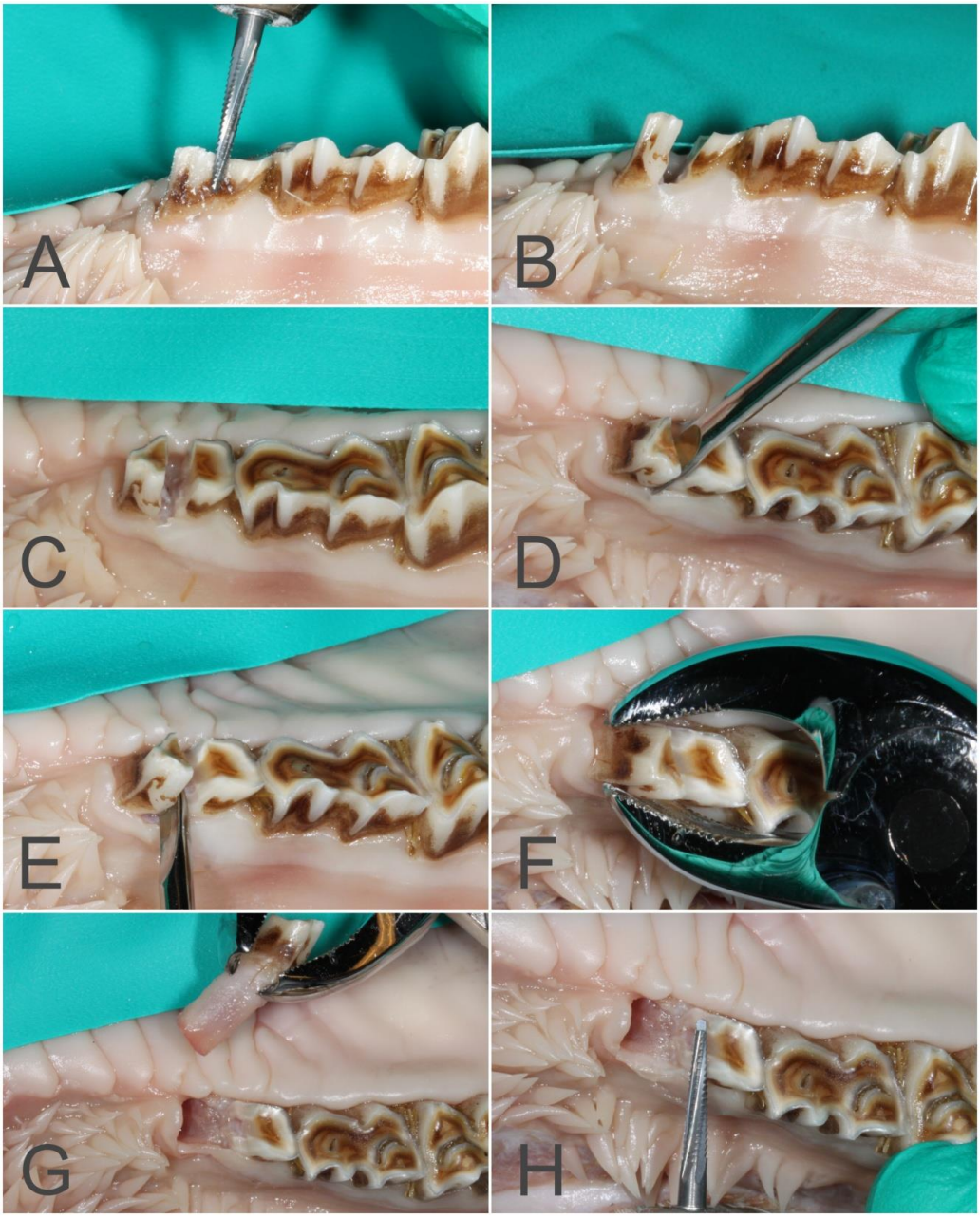


Fig. 20, Hemisection; *(A) The tooth is separated in the furcation, using a bur. (B - C) Almost complete separation of the two root-segments. (D) Definite separation with an elevator, achieved by a mild rotary force. (E) The elevator is then used to loosen the tooth from the alveolar socket. (F - G) When proper movement is achieved, the root is removed with an extraction forceps. (H) Finally, the cut is smoothened.*

4.3 Principal findings

The implementation of different procedures gives rise to the knowledge of where the procedures could and should be performed to maximise the practical outcome. In **Table 5** we have summarised the different procedures performed in the study, suitable areas in the maxilla to perform these procedures and comments on the procedures.

Table 5: Principle findings – suitable areas for surgical execution in sheep's maxilla				
Procedures:	**Suitable areas:**	**Reasons:**	**Comments:**	**Not suitable:**
Extraction	1st deciduous premolar	The 1st deciduous premolar shares most similarities to the human molar, which is important when practicing an extraction.	The 1st deciduous premolar is the most suitable tooth. Extraction in the mandible should be considered.	Permanent molars due to the long and massive root.
Surgical removal of impacted tooth	Impacted permanent molars	To practice the correct location for the incisions and the technique for removing surrounding bone.	Due to the long and massive root of the sheep molars and dense bone tissue, it is very difficult to surgically remove the impacted molars.	Non-impacted teeth
Sinus perforation	Impacted or partially impacted permanent second or third molars	The maxillary sinus is located just above the second and third molars in sheep.	See comment on surgical removal of impacted tooth. For teaching purposes, the impacted molar could be partially removed for the students to practice the flap procedure following sinus perforation.	Deciduous premolars and molars located anteriorly to the impacted or partially impacted molar
Biopsy	Vestibule	Available soft tissue that is not used in other procedures.	This procedure could easily be performed in both maxilla and mandible.	-
Sutures	Anywhere: Interrupted sutures and knots Vestibule: Mattress Between any teeth: Interdental suture 2nd deciduous premolar: Sling-suture (and placement of GTR-membrane) Gingiva/ palate: Periosteal suture	Performance of different sutures is possible to achieve almost anywhere. Furthermore, most of them are performed simultaneously along with other procedures described.	These procedures could easily be performed in both maxilla and mandible.	-
Tunnel	1st deciduous premolar	Proper furcation is necessary, and the 1st deciduous premolar is the only tooth with furcation area	It is necessary to simulate a furcation involvement to perform this procedure as the sheep does not have periodontitis. This could be done with either a Syntette or bur.	Permanent molars due to only on root.

Hemisection	1st deciduous premolar	Proper furcation is necessary	The 1st deciduous premolar has two separated roots and is therefore considered the best option for hemisection.	Permanent molars due to one massive root.
Free gingival graft	Palate: Graft Anywhere in gingiva: Placement of graft	The palate is normally used for harvesting the graft, and the graft could be placed at the gingiva apically to any tooth.	This procedure may be difficult to perform in the mandible alone, as the palate of the maxilla is the best area to harvest the graft.	-

5 Discussion

The aim of this study was to demonstrate how the sheep maxilla could be equally suitable in demonstrating and teaching basic surgical procedures. As opposed to Al-Qareer et al. (2004) and Larsen et al. (2013), not only did we want to demonstrate periodontal surgical procedures, but also include basic procedures in oral surgery. This was in an effort to extend the application of the sheep as a teaching model. In addition, we chose to perform procedures in periodontal surgery that were not performed by neither Al-Qareer et al. (2004) nor Larsen et al. (2013). The reason for this was to supplement the already demonstrated procedures by Al-Qareer et al. (2004) and Larsen et al. (2013).

We noted that the mandible would be more suitable for some of the procedures, particularly the surgical removal of impacted tooth (see **Chapter 5.2**). Nevertheless, the maxilla is suitable as a supplement to the frequently used mandible in both oral- and periodontal surgery. In this way, both the mandible and the maxilla are utilized during the surgical courses and fewer sheep heads are needed.

In Northern Norway the sheep are slaughtered all year round, so the age of the sheep specimens that are delivered depend on what time of year of the delivery. For instance, the sheep delivered in the fall are approximately 4-5 months old, while the sheep delivered in the spring are approximately 8-9 months old. In the present study we primarily used sheep heads that were delivered in the spring time. Thus, all pictures and surgical procedures are carried out on approximately 8-9 months old sheep.

The difference in morphology of sheep premolars and molars makes it hard to compare the sheep dentition to the human dentition. Especially, the sheep molars' massive roots differ a

great deal from human's, and this makes them much less realistic when practiced on. Despite the differences, sheep and humans share several similarities which could be useful in pre-clinical courses. For instance, the sheep's deciduous premolar looks similar to human molars, and the soft tissue in the sheep model could be used to practice suturing, different flap procedures, biopsies etc.

Some of the literature on sheep/ ruminants dentition, and especially the tooth nomenclature, were ambiguous. Thus it is necessary to mention that most of the information about the sheep dentition used in this study is collected from The Viscera of the Domestic Mammals (Nickel et al. 1979), which was received by the Veterinarian Institute of Tromsø. We do not use the tooth nomenclature when talking about the sheep dentition in this study; however the tooth nomenclature is listed in **Table 2**.

To maximize the teaching outcome the undergraduates should receive lectures related to the surgical procedures prior to the laboratory sessions. The undergraduates should also prepare themselves by watching instruction videos made beforehand or read relevant instruction manuals, like the step-by-step instructions for each surgical procedure described in this study.

In the systematic review we first used PubMed and then Google Scholar as another major of the search engine. Google Scholar is a web search engine that gives the user the opportunity to collect articles that have cited an article of interest. In our case, Google Scholar was used to collect all articles that cited a couple of published papers reviewed by Al-Qareer et al. (2004). The fact that articles obtained by Google Scholar are not properly vetted is a big shortcoming to keep in mind.

5.1 Pre-clinical experience for undergraduates at IKO

The only pre-clinical experience the undergraduates at IKO have prior to performing extraction of tooth on patients is to practice the procedure with both elevator and forceps on mannequins. The undergraduates are also taught to perform different sutures with the use of rubber dam and foam. This is the only pre-clinical experience the students have prior to performing these procedures for the first time in patients.

Surgical removal of impacted tooth is lectured and every student gets to observe a supervisor performing the procedure once or twice prior to operating on their own patients.

The undergraduates have some theoretical knowledge of biopsies and flap procedure following sinus perforation but they do not have any pre-clinical practice prior to performing them on patients.

As regards hemisection, tunnel preparation and free gingival graft, the undergraduates receive lectures on these procedures. Some students may also get the chance to observe the procedures performed by a specialist.

5.2 Surgical procedures - sheep versus human

Extraction of tooth: Simple extraction of human teeth has been described in detail by Hupp et al. (2014), and it is reported as a procedure that relies heavily on correct execution technique and no force should be needed. The only suitable tooth to practice extraction, in order to meet this standard, would be the first deciduous premolar. The reason for this is its similarity to human mandibular molars regarding the two separated roots and comparable size. However, one disadvantage of using the deciduous premolar is that there is only one adjacent tooth. The sheep molar is made up of a complex crown and one long and massive root, that distinguishes it a great deal from a human molar. Consequently, the sheep molars are very difficult to extract and would not be realistic to practice.

Extraction in the mandible should be considered. Extraction of incisors, for instance, could be an option to practice rotational movement as well.

Surgical removal of impacted tooth: Mainly because of inadequate space for eruption, the third human molar in both jaws are frequently impacted (Hupp et al. 2014). Due to the age of the sheep specimen, the maxillary second molar is either partially erupted or impacted, which makes the second molar the most convenient. However, as mentioned above, because of the root size of this tooth, the extraction itself would not be realistic and beneficial to practice. The removal of the tooth from its alveolar socket was proven to be very difficult, mostly because of the molar's massive root but also the dense bone tissue affected the result. The procedure described for removal of an impacted human molar (Hupp et al. 2014) could not be followed correctly in the maxilla of the chosen animal model, but practicing removal of bone tissue could still be achieved in a successful manner and hence serve as a useable learning tool.

The third mandibular molar is the most frequent impacted tooth to be removed by the undergraduates, and this procedure could therefore be even more valuable to perform in the mandible. The correct flap technique could then be taught alongside the removal of bone tissue.

Sinus perforation: The diagnosis of a sinus perforation, also known as oro-antral communication, is important to diagnose after removal of human maxillary teeth. The condition is a common complication after removal posteriorly, and it is indicated by either the Valsalva-test or simply by clinical inspection of the post-extraction socket (Fragiskos 2007). It was observed that the impacted second molar in the young sheep was only separated from the maxillary sinus by soft tissue, creating a sinus perforation when surgically removed. Compared to the normal routine were the operator observes the post-extraction alveolus simultaneously as the patient performing the Valsalva-test (Fragiskos 2007), this is not possible in the sheep's maxilla. Therefore, the diagnosis of oro-antral communication is based on clinical inspection only. Due to the third molar being too difficult to be surgically removed, it would be inconvenient for the undergraduates to make a real sinus perforation occur. Thus, to get to practice this procedure, it is necessary to simulate or envision a sinus perforation. This could be achieved by only partially removing the impacted third molar or any other tooth in the maxilla, and then performing the flap procedure following sinus perforation.

Biopsy: When performing a biopsy the administration of local anaesthesia, the outline for incision and the actual surgical removal is thought to be the most important. Principles for successful outcome of biopsy in humans includes avoidance of injection of local anaesthetic into the inside of the lesion and use of forceps at the pathologic part (Fragiskos 2007). The biopsies available include excisional-, incisional-, aspiration- and needle biopsy, whereby the technique is determined by indication and extent of the pathological lesion (Fragiskos 2007). The most suitable area in the sheep maxilla to practice excisional biopsy is the vestibule, were the loose mucosa gives the students a realistic instrument handling. Actually, most locations, in the maxilla are useful performing this specific procedure. Despite the absence of an actual lesion in most of the specimen, the procedure could be performed as described for humans (Fragiskos 2007). Other areas suitable for biopsy may be the sides of the tongue and vestibule in the mandible.

Sutures: The sutures demonstrated in the study are basic sutures the undergraduates should be able to perform, like simple interrupted suture and mattress suture (Fragiskos 2007). Other sutures demonstrated are sutures primarily used in periodontal surgery, like sling suture and periosteal suture. The sling suture demonstrated is used in placement of membranes during guided tissue regeneration first described by Gottlow et al. (1986), and the periosteal suture in procedures like the free gingival graft first described by Sullivan and Atkins (1968). With correct thawing process, the soft tissue will remain relatively fresh and hydrated, giving a realistic feel to it. Thus, the students get to practice their suturing technique and instrument handling on human-like tissue instead of rubber dams and foam. The attached gingiva, mucogingival junction and alveolar mucosa are all suitable areas to practice suturing. The tongue and buccally to the incisors may be other areas to be considered.

Tunnel preparation: The tunnel preparation is performed by raising an apically repositioned flap (Friedman 1962; Nabers 1954), and then preparation of the furcation entrance (Lang and Lindhe 2015). The first deciduous premolar in the sheep maxilla has a resemblance to a mandibular first molar in human, as it has two separated roots with appropriate root divergence. This makes the first deciduous premolar ideal for practicing the tunnel preparation. No periodontitis was found in the sheep specimens. Thus, a furcation involvement degree III must be simulated by drilling through the furcation area with a round bur and micro motor. Regardless, the procedure is feasible and the students would likely get a better comprehension of the surgical technique and instrument handling. The massive roots of the sheep molars make them inadequate to practice on. The procedure may also be practiced on the first deciduous premolar in the mandible.

Free gingival graft: The free gingival graft procedure, first described by Sullivan and Atkins (1968), was performed at the mucogingival junction above the maxillary molars. The gingival graft was harvested from the hard palate approximately where the graft could be harvested in humans, close to the second molar (Studer et al. 1997). The procedure could be performed more or less like it is performed in humans (Lang and Lindhe 2015), and the sheep then serve as a good teaching model. The free gingival graft procedure could be practiced at several other locations as long as there is attached gingiva with an apparent mucogingival margin.

The procedure may also be performed in the mandible. However, the most adequate area to harvest the gingival graft is the palate in the premolar area, the palate close to the second

molar and the tuberosity (Studer et al. 1997). The maxilla is hence most suitable for this procedure if it should resemble the conditions in periodontal surgery performed on human patients.

Hemisection: Hemisection is a surgical procedure where a defected root together with the corresponding crown portion, are surgically removed (Lang and Lindhe 2015). Thus, the first deciduous premolar is the only suitable tooth to practice this procedure, due to its two separated roots. The massive roots of the sheep molars make them inadequate to practice on. The procedure have good long term survival rate, and should be a surgical approach to consider under the right circumstances (Huynh-Ba et al. 2009). Using the deciduous premolar, the procedure could follow the technique as described in terms of surgery performed on humans (Lang and Lindhe 2015).

The procedure may also be performed in the sheep mandible, using the deciduous premolars (Larsen et al. 2013).

In general: Common for all the procedures; the practice of surgery on the sheep model will improve handling of instruments and surgical skills like precision and effectiveness. The students will get a better understanding of the surgical procedures, and the opportunity to practice surgery in a calm and safe environment.

5.3 Cost versus benefits

In Norway, sheep heads are quite easy to obtain and cheap to purchase. The local butcher, whom the University of Tromsø collaborates with, informs of costs with a nominal value of 20 NOK per head. The distributor, on the other hand, informs of costs of 150 NOK per head. With regards to such large differences in purchasing cost, the butcher should be the choice. The sheep is mainly farmed for meat and wool, and the head is only partly used for this purpose. The heads are only used as meat up to the age of 18 months, afterwards the brain and spinal cord is considered risk waste (SRM). Furthermore, the destruction of biological waste is expensive for the butcher therefore a collaboration with educational programs would benefit both parties.

5.4 Organization

By choosing the maxilla as the teaching model in this study, both the maxilla and the mandible could be used in a learning context at the university, and thereby less heads are needed to supplement the clinical instruction. This idea would favor both purchasing costs for the educational program as well as the ethical aspect regarding the animal. Below are a proposal for organization with respect to the clinical experience of the dental undergraduates, the scheduled course in periodontal surgery and how to organize the sessions (see **Table 6 and 7**). The students are assigned to groups of two to three. Stations to perform each procedure are made. Each station contains either a maxilla or mandible based on which procedure to be performed. The students will rotate between each station, operating and assisting each other, until everyone has performed each procedure. The time schedule and proposal for organization are just examples and based on the curriculum at the University of Tromsø. Other educational programs should organize the sessions based on their curriculums.

Table 6: Semester suitable for execution of different surgical procedures on sheep's maxilla

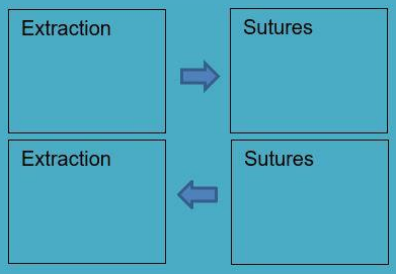
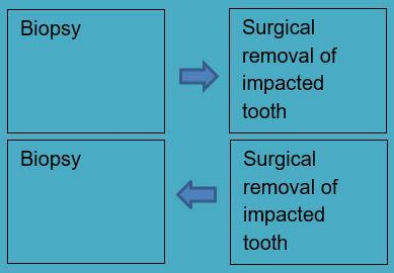
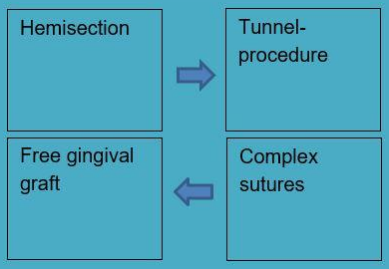
6th semester (2 – 3 students each group) 	• Maxilla - Sutures - Extraction - Procedures after sinus perforation - Course: April
8th semester (2 – 3 students each group) 	• Mandible - Periodontal surgery - Course: April (scheduled) • Maxilla - Biopsy - Surgical removal of impacted tooth - Course: March
9th semester (2 – 3 students each group) 	• Mandible - Periodontal surgery - Course: September (scheduled) • Maxilla - Hemisection - Tunnel-procedure - Free gingival graft - Course: September

Table 7: Possible organization of surgical course on sheep's maxilla		
Duration: 2 days	**1st day**	**2nd day**
Group assignment: 10 students per group Principe: Rollover 6th and 8th semester: 1 rollover (approx. 1.5 hours each station) 9th semester: 3 rollovers (approx. 45 min each station)	Group 1: 08.15 – 11.30 Group 2: 12.15 – 16.00	Group 3: 08.15 – 11.30 Group 4: 12.15 – 16.00

5.5 Future aspects

Initially we wanted to take radiographs of the sheep maxilla to get a better view of the anatomy, with emphasis on the sinus system and its relation to the impacted third molar. With minimal research we excluded the idea due to contamination risk. However, this should be considered in a future study. Perhaps the Veterinarian Institute could be of assistance in this regard.

Literature on the anatomy of the sheep head was scarce. We collected information about the anatomy and morphology of the dentition through articles and literature received from the Veterinarian Institute, and provided remaining information needed through our own examination of the sheep maxilla. The morphology of the dentition and surrounding bone structures was studied by extraction of teeth and removal of bone tissue. We removed some of the bone tissue buccally to the molars by drilling. This proved to be very difficult due to the dense bone tissue and an ineffective micro motor, thus we recommend using a more effective micro motor in future studies. A more thoroughly examination of the sheep head and dentition is needed to be certain of the anatomy.

Implementation of the sheep as a teaching model could benefit the undergraduates by improving technical skills in oral- and periodontal surgery. Due to a restricted timeline it was not possible to make an evaluation of teaching outcome among undergraduates after performing surgery on sheep heads. This could preferably be done by implementation of a questionnaire in future studies.

In retrospect, perhaps it would have been more informative to demonstrate the same procedures as Al-Qareer et al. (2004) and Larsen et al. (2013), in order to compare these procedures' suitability in the maxilla versus mandible. This could be an idea for future studies.

6 Conclusion

The sheep maxilla has proven to be a suitable model for practicing and teaching a variety of periodontal and oral surgical procedures. Incisions, flap designs, bone removal with burs, sectioning of teeth with burs and elevator, debridement and suturing techniques could all be conducted in a realistic and satisfying manner. Additionally, the model is suitable for injection techniques, techniques for biopsy, and placement of surgical membranes. This makes the sheep maxilla a good supplement to the already studied sheep mandible.

Because of lack of blood and salivation in the surgical field, the model gives the opportunity to visualize and grasp the significance of each step of the different procedures performed. Since the sheep maxilla is providing a great representation of the human maxilla in terms of tissue texture, location of sinuses, the occurrence of periodontal pathology, size and more, it would really be a model to consider for teaching dental undergraduates in oral- and periodontal surgery. Using a sheep cadaver in teaching circumstances provides the opportunity to learn by doing, development of surgical skills, better understanding of instrument handling and tissue responses. Not to mention, the sheep cadaver is easily obtainable and inexpensive to purchase.

The model based on the sheep maxilla is potentially very useful in teaching undergraduates in both periodontal and oral surgery, and the use of a more realistic teaching model would hopefully result in greater learning outcomes for the students. However, additional studies are needed to validate this model within a teaching environment.

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