Thiel Embalming Technique: A Valuable Method for Teaching Oral Surgery and Implantology

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ABSTRACT

Background: Because of its high requirements on surgical experience and the need of complete understanding of the anatomy, oral surgery and especially implantology belong to the most demanding procedures in dentistry. Therefore, hands-on courses for oral surgery and implantology are considered a prerequisite to prepare for clinical practice. To achieve teaching conditions as realistic as possible, we used a novel human cadaver embalming method enabling tissue dissection comparable with the living body.

Methods: Thirty cadavers which were offered by the Institute of Anatomy for the purpose of running oral surgery and implantology courses were embalmed in the technique described by Thiel. On each cadaver, dissection of soft and hard tissue and implantological procedures were performed according to a structured protocol by each course participant. The conservation of fine anatomical structures and the suitability of the embalmed tissue for dissecting, drilling, and suturing were observed and photographically documented.

Results: By means of the Thiel embalming technique, oral surgery and implantological procedures could be performed under realistic conditions similar to the living body. Due to the conservation procedure, preparations could be carried out without any time limit, always maintaining the same high quality of the tissue. The maxillary sinus membrane, mucosa, bone, and nerves could be exposed and allowed dissecting, drilling, and suturing even after weeks like fresh specimens.

Conclusion: The Thiel embalming method is a unique technique which is ideally suited to practice and teach oral surgery and implantology on human material.

KEY WORDS: implantoloy, oral surgery, surgical course, Thiel embalming technique

INTRODUCTION

Oral surgery and especially implantology belong to the most valuable procedures in dentistry. Therefore, application of the different techniques is mandatory for the optimal treatment of the patients. Because of its high requirements on surgical experience and the need of complete understanding of oral anatomy, significant effort is necessary for the reliable mastery of these demanding procedures. Due to the fact that learning of bone management procedures, performing different augmentative techniques, and inserting implants the first procedures in clinical cases will lead to a high risk of implant failure and loss. Therefore, the field of implantology is often reserved to experienced surgeons. To overcome this problem, a number of models for teaching and exercise of oral surgical and implantological procedures have been developed. Although these models are very useful for the preparation of young surgeons to perform oral surgery and implantology on the patient, they are characterized by certain disadvantages. For example, flap raising courses are carried out either on fresh and therefore potentially infectious cadavers or on corpses which are embalmed using the conventional formalin fixation procedure. Whereas fresh cadavers

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provide for optimal conditions of surgery, they can only be used for a limited time period due to the inevitable decaying process. On the other hand, formalin cadavers enable the learning oral surgeon to safely perform dissections without temporal limitation, but caused by this embalming procedure, the tissue is unsuitable for reliable exposure of anatomical structures like the maxillary sinus membrane and nerves or for performing delicate dissection procedures like sinus floor elevation, nerve lateralization or soft tissue augmentations. Moreover, courses for learning or improving oral surgical skills and implantological procedures are exclusively performed on animals or alloplastic materials. Thus, the challenge of the first sinus floor elevation or the task of nerve lateralization under realistic conditions can only be fulfilled so far by practicing directly on the patient.

In this paper a technique is described which provides oral surgery and implantological procedures to be carried out under realistic conditions without temporal limitations and which therefore represents a valuable contribution for teaching purposes.

MATERIAL AND METHODS

Since May 2003, 30 cadavers were provided by the Institute of Anatomy of the Ruhr University for the purpose of running courses for oral surgery and implantology. All cadavers have been embalmed using the method which was described by Thiel. The embalming solution is composed of numerous ingredients with the aim to conserve texture, volume, color, and shape of the body as perfect as possible. A fundamental basis of the solution is its high concentration of salt components causing a denaturation of proteins. This precipitation leads to a homogenization of the tissue. The physiologic texture of the tissue is maintained by further effects of precipitation and linking up caused by the embalming solution. There is no shrinking or soaking of the soft tissues. With the composition of the solution, the different components and tissue characteristics of the body are taken into consideration. The basic components of the Thiel Solution are listed in Table 1.

TABLE 1 Components of the Thiel Solution

Basic Components of Thiel Solution	
Hot tap water	100
Boric acid	3
(Mono-)Ethylenglycol	30
Ammoniumnitrate	20
Potassiumnitrate	5
Chlorkresol-solution with (Mono-)Ethylenglycol	10
4-Chlor-3-Methylphenol	1

Liquids are given in milliliters; solid components are given in grams.

For fixation of the different compartments of the corpse, the basic solution is correspondingly modified and separately infused (Table 2). After infusing the basic and tissue-specific solutions over 3 days, the cadavers are stored in a special container solution (Table 3). To achieve an optimal result, this conservation should last about 6 months.[1,2]

Five cadavers were used for each course, and the number of participants, most of whom were dentists, oral surgeons, and maxillofacial surgeons was limited to 10. Each course lasted for 2 days and was divided into four parts. Every part consisted of theoretical

TABLE 2 Composition of Tissue-specific Solutions

	Tissue-specific Solutions		
Component	Corps infusion solution	Entrails solution	Brain and spinal cord solution
Basic solution	14,300 mL	10,000 mL	
Chlorate kresol solution	500 mL	500 mL	
Sodium sulphate	700 g	500 g	
Formalin	300 mL	850 mL	10 mL
Morpholin		300 mL	
Isopropylalcohol		3,000 mL	40 mL
Tap water			40 mL
(Mono)Ethylenglckol			10 mL

TABLE 3 Composition of the Thiel Container Solution

Container Solution	
Hot tap water	100
Boric acid	3
(Mono-)Ethylenglycol	10
Ammoniumnitrate	10
Potassium nitrate	5
Chlotrate kresol solution	2
Sodium sulphate	7
Formalin	2

introduction followed by practical exercise. The different surgical procedures and operations were carried out by each participant step by step after detailed anatomic description and with continuous supervision and assistance by the instructors. The course program covered basic surgical procedures like osteotomies of teeth, soft tissue management, closing of oro-antral fistulas, and alveolotomies. On the next surgical level, bone management was the main topic. Here, the participants learned different methods of harvesting bone grafts, bone augmentation techniques, and sinus floor elevation. On the third surgical level, neurolysis of the mental nerve and lateralization of the inferior alveolar nerve were performed with and without the assistance of piezosurgery. During surgical procedures of level two and three, dental implants were inserted under different circumstances and bone supply in the lower and upper jaw. Of course an individual program for every cadaver was mandatory for appreciating each local situation and amount of available teeth. When one part of the surgical procedures was finished, the different anatomical sites were demonstrated to all 10 participants and different possibilities to deal with the specific anatomical situation were discussed.

RESULTS

The outward appearance of the cadavers showed a pale, sometimes reddish skin coloring. Due to the embalming procedure, the superficial epithelial layers and the nails peeled off and were completely removed before starting the courses. This peeling could be avoided by treating the bodies with a high percentage of formalin solution, but this was not necessary for the purpose of the courses. The skin was smooth, slightly oily, and completely hairless. The gingiva was tense and fixed to the underlying alveolar bone and the mucosa was smooth and slightly pink (Figure 1). Compared with the living, the embalmed skin, gingiva, and mucosa were insignificantly tighter but could be incised with a sharp scalpel without using pressure (Figure 2). The subcutaneous and submucous fatty tissue had retained its yellow color and its typically small or large fat lobules. The fascias of the masseter muscles could be identified as silvery shimmering structures with intact fiber orientation. The muscles were tight, red, and their contained vessels or nerves nearly did not differ from those of the living. They could be dissected without problems.

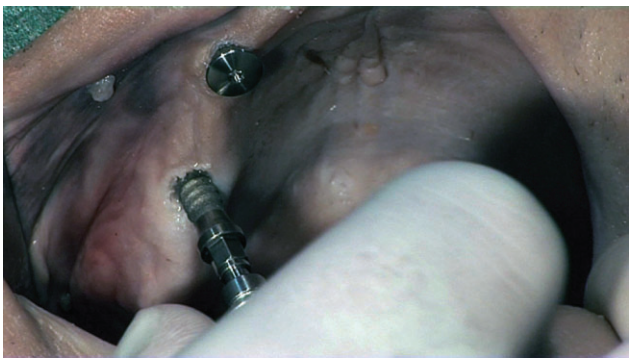

Figure 1 Loading of implants into the upper jaw.

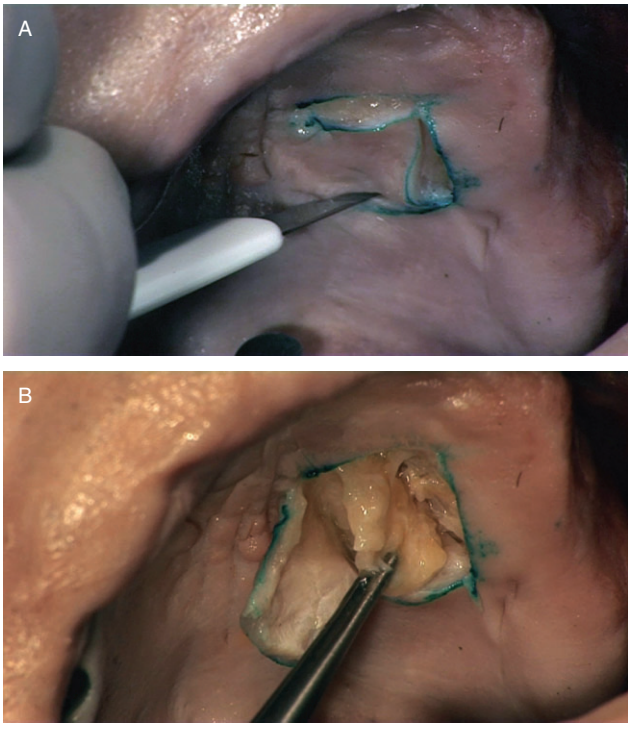

Figure 2 Raising a soft tissue graft from the palate; circumcision of the donor site (A) and dissection of the graft.

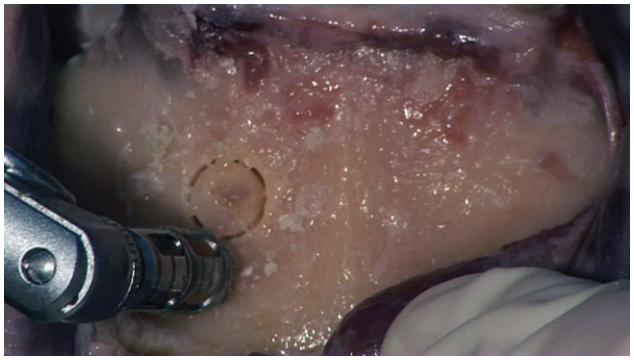

Figure 3 Harvesting bone grafts by cylindric drilling in the mental region.

Besides the tissues already described, the quality of bone was of decisive importance for running implantological courses. Hereby we found that the alveolar bone in the upper and lower jaw was perfectly preserved and could be dissected like in the clinical setting (Figures 3 and 4). Even cases with a very small alveolar ridge could be loaded with dental implants in the usual manner without fracturing. When cutting vessels, the little sticky Thiel solution was washed out, and the vessels were cleansed so that the venous vessel walls collapsed, whereas the lumina of the arteries were kept open by the tunica media.

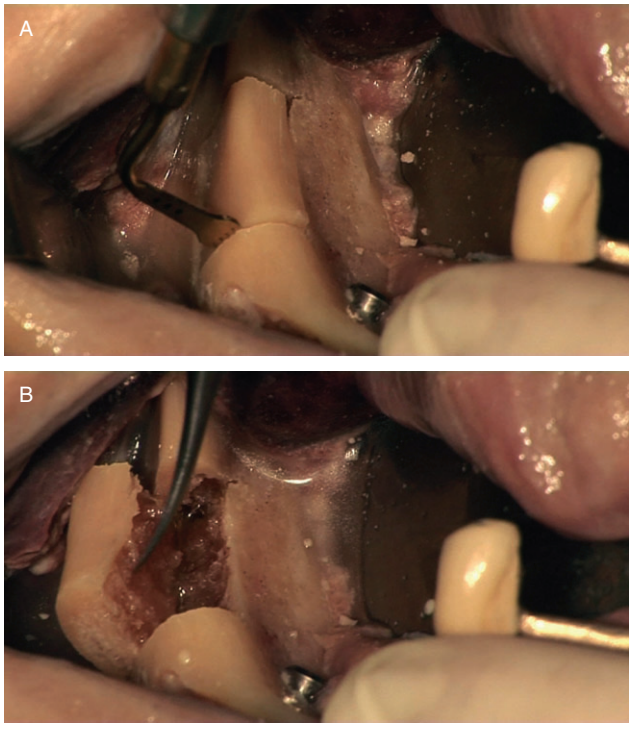

Figure 4 Harvesting a corticospongeous bone graft using piezosurgery for the cortical bone (A) and collecting further spongious bone (B) in the right posterior alveolar ridge of the mandible.

Figure 5 Lateralization of the right inferior alveolar nerve.

For conservation of the peripheral nerves in the oral region, that is, infraorbital, mental, alveolar inferior, and branches of the facial nerve, the Thiel technique did not lead to results as optimal as in the vessels. Here, compared with fresh nerves, the structure was a little weaker, and the nerve bundles were less compact (Figure 5). Nevertheless, even branches of the facial nerve were also detectable via the intraoral approach. Even the most difficult procedures like sinus floor elevation and fixation of bone grafts were adequate to the living operative situs (Figure 6).

Due to the typical flexibility, structure, pliability, and tightness for each component of the soft tissues described, dissecting of gingiva and mucosa as well as raising free gingiva flaps from the palate could be carried out successfully by all participants of our courses. By the

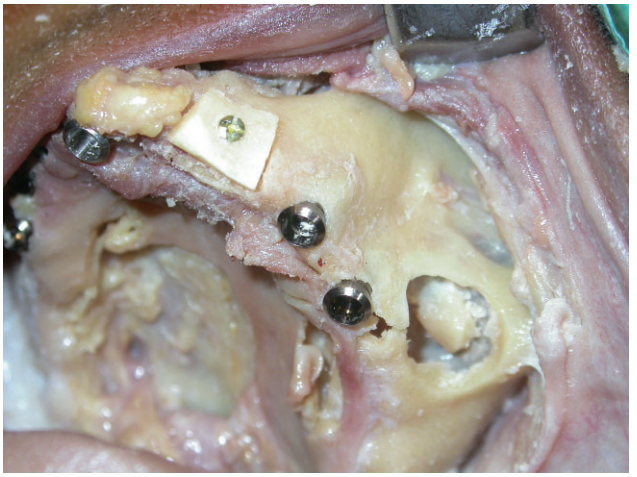

Figure 6 Left upper jaw after sinus floor elevation and cortical augmentation in left upper canine region.

end of the first course day, the cadavers were covered with clothes soaked with the fixation solution to prevent the drying up of the bodies; thus, preparations could be continued over the following day under the same conditions without any pressure of time. After finishing the course, the cadavers were kept up for further purposes, such as teaching of endoscopic approaches, free flap raising courses or dissections at the vertebrae or joints.

DISCUSSION

Whereas many surgical skills can be achieved by practicing directly on the patient, there is general agreement about the usefulness of courses for implantological surgery and related operations such as difficult bone augmentations or sinus floor elevations before starting on a clinical case.[3–8] With this, various reasons can be given, like the fear of increasing expenses in the case of complications, or the conviction that technically highly demanding procedures only can be taught in specifically organized courses.[4–6,9] Moreover, ethical doubts come up when difficult operations have to be studied and exercised in a living patient.[4,6,10]

Teaching courses for oral surgery and implantology are particularly challenging because the surgeon first has to comprehensively understand the exact anatomical positions and variations of the exact bone structure and nerves as a prerequisite of successful approaches and placement, second, he has to acquire the necessary skills to work with fine surgical instruments, for example, during a sinus floor elevation, third, he has to study in which cases bone or soft tissue grafts are mandatory and where and how to get them, and fourth, he has to learn the patience for difficult surgical cases which often do not belong to the spectrum of his daily work.

The British General Dental Council (GDC) tried to set standards on implantology by asking general dental practitioners for a special implantological certification. This says that general dental practitioners should complete a course in implant dentistry and undergo mentoring until the experienced implant clinician considers the practitioner to be competent.[9] This setting of training standards by the GDC has to be appreciated because they realized the problem of inexperienced surgeons performing difficult operations. But their solution to this problem means that the same inexperienced surgeons still practice primarily on the patient. Would it not be safer to exercise these difficult procedures on invulnerable models first?

To fulfill these requirements, the courses must cover all important steps and aspects of pure and related implantological procedures and allow for hands-on working without temporal restrictions.

Because implant alignment can only be learned by studying the human anatomy, courses are carried out using either fresh corpses, which mostly were conserved by freezing, or formalin-embedded corpses. Obviously, both methods have specific advantages and disadvantages. In fresh cadavers, the anatomical structures are well preserved, but they can be used only over a limited time period; moreover, fresh cadavers carry the risk of infectious diseases. On the other hand, formalin cadavers are not being subjected to a rapid decaying process but do not provide for a tissue quality comparable with clinical conditions. The main disadvantages of the formalin fixation are stiffness and unnatural coloring of the tissues.

Moreover, fine tissue structures like the membrane of the maxillary sinus, which is decisive for successful bony augmentation and therefore for loading of implants, are not maintained properly. Regarding sterility, the Thiel procedure does not show any disadvantage compared with formalin but provides a better protection against fungal infections.[1,2,11,12]

Implantology courses which have been established at many centers successfully are based on training models using either virtual reality models or models consisting of synthetic material or animal models like pig mandibula[12]or sheep corpses.[4,7,13–15]

It's hard to say which of these methods is the best. Via virtual reality programs (VR), basic knowledge can be gained in self studying, moreover, it is relatively cheap. But apart from that, VR has one big disadvantage: no resistance or force feedback.[11] But it could be evaluated as an appropriate first step of surgical training.[14] Animal models on the other hand present similar tissue characteristics like humans but differ in bone and tooth morphology.[11,12] Therefore, they have only limited capabilities. Synthetic models consisting for example of composite material, are accepted as a first approach because there is basically unlimited access, they can be used several times and therefore they are relatively cheap.[2] Because of its limited similarities to tissue characteristics, Groscurth et al. state that it must not be the only model.[2] In summary, none of these three models is

offering the chance to work in human oral cavity with authentic tissue handling and specificity in bony formation.

The Thiel embalming method however provides suitable conditions for the program of this course. It presents a perfect model for hard tissue as well as soft tissue manipulation. Besides the basic techniques like osteotomy of teeth and alveolotomy or closing oro-antral fistulas, it also suits more difficult tasks like bone graft harvesting, bone augmentation techniques, loading implants, and sinus floor elevations. Also, for neurolysis of the mental and inferior alveolar nerve, it provides a good training facility.

Furthermore, it would be interesting to have a direct feedback from the participants in these courses in form of a structured questionnaire. Although this would be subjective data, ratings regarding manageability, tissue structure, and proximity to the real life situation would help to compare this method with other established training models.

Due to the fixation of the corpses, the operation time is not limited by decaying processes so that all relevant steps could be performed in a comfortable working atmosphere. Doing this, the specific properties of oral cavity could be compared, helping the course participants to learn about different types of intraoral morphology, for example, the various dimensions of the maxillary sinus, and study anatomical variations. The only disadvantage of the technique described here is that the fixation procedure needs up to 12 months and thus produces relatively high costs for processing over months.[1,2,12] Moreover, storage is not possible together with formalin embalmed cadavers so that separated containers are necessary. Nevertheless, keeping a relation of two course participants per cadaver, a justifiable calculation of costs is possible. In addition, it is possible to use one cadaver for several different surgical courses, for example, orthopaedic surgery, neurosurgery, flap raising, or endoscopy.

CONCLUSION

Evaluating our 5-year experience, we can state that cadavers embalmed in the technique described by Thiel have remarkable advantages for running oral surgery and implantological courses.

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