

Perception of Surgical Faculty on the Utility of Modified Thiel Embalmed Cadavers

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ABSTRACT

Introduction: Surgical skills training on low and high fidelity simulators have been in practice for over a decade, but due to the high cost of virtual reality simulators it is beyond the reach of institutions and trainees. Among the simulators, high fidelity simulators such as a suitably prepared human anatomical specimen would give a real feel as if doing the procedure in the living. Hence, having soft, supple cadaver with organoleptic properties is an ideal situation for training by simulation and research. To facilitate the surgical skill training and research, chemical embalming was adopted with modifications of the Thiel method, for cadaver preservation.

Aim: The aim of this study was to study the perception of the surgical faculty's experience on the utility of modified Thiel embalmed cadavers for surgical procedures.

Materials and Methods: In this cross-sectional study, a feedback was taken from practicing surgeons of broad and sub specialties such as general surgery, orthopedic surgery, neurosurgery, plastic surgery, pediatric surgery, ophthalmology, ENT, OBG, Transplant surgery (n=54). A 5 point Likert scale questionnaire was used with criteria

of measurements like skin color, consistency, odour, differentiation of the layers, approach to the area, joint mobility and suitability for the procedure.

Results: The scores ranged from 3.9 to 4.46/5. The participants expressed satisfaction on the cadaver quality on their utility for performance of surgical procedures. They expressed that, such embalmed cadavers would be excellent for learning purpose, surgical skills training in orthopedic procedures like arthroscopy. They felt the joint mobility was good, the consistency was soft and differentiation of layers was good. Some felt the tissues were fragile and would easily give away losing their strength.

Conclusion: Thiel embalmed cadavers retain their organoleptic properties and hence facilitate surgical skills training. The thiel embalmed cadavers have been used for many procedures like thyroidectomy, mastectomy, laparoscopy, flaps, nasal endoscopy and have been found suitable for surgical skill training. The only hindrance in the usage of the modified thiel embalmed cadavers is brain related procedures as the brain is not effectively embalmed and the high cost of chemicals involved in embalming.

Keywords: Embalming, Supple cadavers, Surgical skills

INTRODUCTION

Simulated learning in the medical profession has been in existence for a long time. The beginnings of the medical training were with the formalin embalmed cadaver specimen in the anatomy lab-an excellent method of learning gross anatomy, but the body parts become firm and fixed by the routine, traditional and old method of formalin embalming which will not help to perform or practice surgical skills on such cadavers. Surgical skills training on low and high fidelity simulators have been in practice for over a decade, but due to the high cost of virtual reality simulators, it is beyond the reach of institutions and trainees. Under these circumstances the standard method of learning surgical skills is 'on the job'

learning from peers and professors. Trying out basic surgical skills and operative procedures on simulators have been proven to be beneficial to the students and also increase their confidence levels when treating the living. It also has an advantage of improving patient safety [1,2].

Among the simulators, high fidelity simulators such as a suitably prepared human anatomical specimen would give a real feel like as if doing the procedure in the living. To facilitate this, cadavers have to be soft, supple and flexible. The fresh cadavers are the best to create such an experience but short shelf life (few hours), early putrefaction, offensive odour and exposure to infective organisms and difficulty in procuring are hindrances for their optimal utility. Chemically preserved

cadavers overcome the disadvantages of fresh cadavers but at the cost of losing part of the organoleptic properties.

The conservative formalin embalmed cadavers are rigid, dark coloured and hard. This will not allow the surgeons of various specialities to train themselves or try out new procedures as in living. The surgeons cannot position the formalin embalmed cadavers as the operative procedure demands. Mobility of joints and tissue for dissection is completely lost thereby making dissection difficult. Hence, the experience of the surgeon is not mimicked as in living. If the cadavers are preserved in a way that is suitable for the surgeons to position them, dissect layer wise, move and retract the tissue/viscera, apply sutures, conduct anastomosis as they do in living scenarios, then such cadavers become an excellent learning tool for surgical skills development.

Hence, having soft, supple cadaver with organoleptic properties is an ideal situation for training and research.

Soft embalming or Thiel embalming was initiated and established at the University of Graz, Austria by professor Walter Thiel and then spread to other European Universities. Since 1992, the Thiel embalmed cadavers are being extensively used for cadaver preservation for surgical skill training especially in European countries [3,4].

In India, formalin embalming is still the gold standard for cadaver preservation for anatomical studies, despite the fact that it has been found to be carcinogenic. Few centers are trying alternate methods with little success. Keeping the benefits of surgical skill training in mind, the M S Ramaiah Advanced Learning Center was started in 2011, a surgical and medical skills training center. To facilitate the surgical skill training and research, chemical embalming was adopted with modifications of the Thiel method, for cadaver preservation.

The objective of this study is to analyse the perception of the surgical faculty's experience on the utility of modified Thiel embalmed cadavers for surgical procedures.

MATERIALS AND METHODS

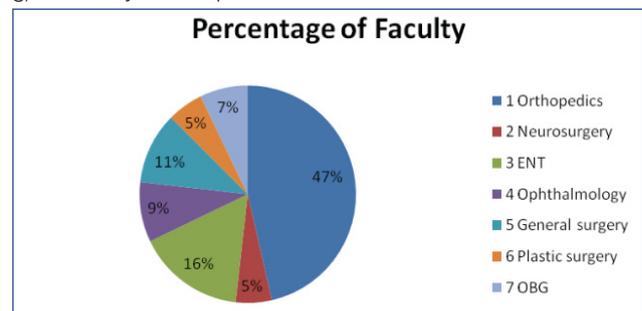
This cross-sectional study was conducted in the Department of Anatomy at M S Ramaiah Advanced Learning Center, Bengaluru, India, during the year 2014-2016. Ethical clearance was taken from the institutional ethics committee. A 5 point Likert questionnaire (Annexure 1) was prepared and validated by expert faculty in Anatomy and Orthopedics Department (Face validity). A pilot study was also conducted for 10 participants. The participants for the study were from Surgical faculty from broad and subspecialties such as General Surgery, Orthopedics, Neurosurgery, ENT, Ophthalmology, Plastic surgery, Paediatric surgery, OBG [Table/Fig-1]. Cadavers for the workshops were prepared by modified Thiel embalming solution. Informed consent was taken from all the participants.

The participants attending to the workshop were allotted to each of the cadavers. The questionnaire was administered randomly as and when the participants completed the procedures on the cadavers. The total number of participants was 54 from various kinds of workshops. The total number of cadavers used for various surgical procedures were 25. [Table/Fig-2] shows the list of procedures performed by various participants.

These surgeons were from M S Ramaiah Medical College and other medical institutions who came as resource persons/ expert faculty and as participants to the Cadaver lab courses organized at the M S Ramaiah Advanced Learning center.

The criteria used were-

- a) Skin colour,
- b) Odour,
- c) Consistency,
- d) Differentiation of the layers and approach to the area,
- e) Joint mobility
- f) Mimics a living tissue.
- g) Suitability for the procedure done.



[Table/Fig-1]: Demonstrates various faculty using the modified Thiel embalmed cadavers.

S. No.	Speciality	Procedures Done
1	Orthopedics	Knee arthroscopy and arthroplasty, Hip arthroplasty, Shoulder arthroscopy, Trauma-upper and lower limb.
2	Neurosurgery	Spine surgery.
3	ENT	Endoscopic sinus surgery, Rhinoplasty, Facial plasty, Nasal endoscopy, Temporal bone dissection.
4	Ophthalmology	Ociculoplasty, Ocular surgeries, Periocular aesthetics.
5	General Surgery	Intestinal anastomosis, Thyroidectomy, Mastectomy, Cholecystectomy, Laparotomy, Axillary lymph node dissection, Colectomy and Sigmoidectomy.
6	Plastic Surgery	Facial plastic surgery.
7	OBG	Laparoscopic hysterectomy.

[Table/Fig-2]: List of procedures done by various surgical faculty members.

S. No.	Criteria	Strongly Agree (%)	Agree (%)	Not Sure (%)	Disagree (%)	Strongly Disagree (%)
1	Colour is as in living tissue	10 (18.5%)	38 (70.37%)	6 (11.1%)	0 (0%)	0 (0%)
2	Consistency is similar to as in living tissue	12 (22.22%)	35 (64.8%)	5 (9.25%)	2 (3.70%)	0 (0%)
3	Odourless	15 (27.77%)	34 (62.96%)	5 (9.25%)	0 (0%)	0 (0%)
4	Layers can be differentiated well	19 (35.18%)	28 (51.85%)	5 (9.25%)	2 (3.70%)	0 (0%)
5	Approach to the area is good	16 (29.62%)	34 (62.96%)	2 (3.70%)	2 (3.70%)	0 (0%)
6	Mimicks live tissue	16 (29.62%)	27 (50%)	9 (16.66%)	2 (3.70%)	0 (0%)
7	The joint mobility was good	25 (46.29%)	26 (48.15%)	3 (5.55%)	0 (0%)	0 (0%)
8	Suitable for the procedure done	32 (59.25%)	16 (29.62%)	3 (5.55%)	3 (5.55%)	0 (0%)

[Table/Fig-3]: Demonstrates the rating of different qualities of Thiel embalmed cadavers by the participants.

STATISTICAL ANALYSIS

The scores given in the questionnaire by the participants were analysed and the mean of the scores were calculated and tabulated. The percentage of scores of each of the individual participant was calculated. The percentages were categorised as follows: $\geq 75\%$ were excellent cadaver quality, 65-74% as Good cadaver quality, 51-64% as average cadaver quality and $\leq 50\%$ as poor cadaver quality. Photographs of cadavers in different operative positions were taken to indicate the flexibility of the cadaver.

Please Note: As the surgical skill lab wants to go for proprietorship with respect to the modified Thiel embalming solution, the constituents of the modified embalming solution has not been revealed in the study. The modified Thiel solution is different from original Thiel composition by some chemicals are not included as they are not available in India and few chemical concentrations have changed.

RESULTS

The responses from the practising surgeons were positive regarding its utility for procedural skills training.

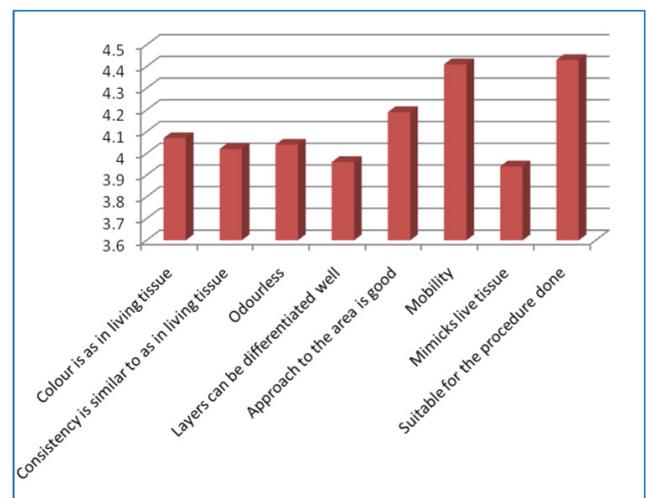
[Table/Fig-3] demonstrates the percentages of participants with their scores for each of the criteria mentioned in the questionnaire.

The quantitative data showed an average scoring of 4/5 and above as shown [Table/Fig-4].

Each participant's scores were added up and the percentage score was calculated and analysed as in the [Table/Fig-5]. Total 87.03% of the participants have scored more than 75% regarding the suitability of the cadaver for the procedures they performed on the modified Thiel embalmed cadavers [Table/Fig-6].

The qualitative data received was analysed and reported criteria wise as follows.

The descriptive comments were mainly on odour, consistency and mobility of tissues, colour and preferability of usage for different procedures.



[Table/Fig-4]: Showing the average of the scores for each of criteria in the questionnaire.

Sl. No.	Percentage of Score	Number of Participants (%)
1	$\geq 75\%$	47(87.03%)
2	65-74%	2 (3.70%)
3	51-64%	5(9.25%)
4	$\leq 50\%$	0 (0%)

[Table/Fig-5]: Showing the number and percentage scored by the participants regarding suitability of the modified embalmed cadavers for the procedures done.

Colour

Many participants expressed the colour to be natural, normal, fresh and hypopigmented skin.

Odour

Most of them expressed the odour to be insignificant but a few have expressed as slight pungent odour, fruit like odour, tissue smell present.

Consistency of Tissue

The participants expressed that the tissue consistency was soft and natural. They felt the identification of tissue was easy. A few plastic surgeons felt the tissue to be lax especially the



[Table/Fig-6]: Showing the different positions for different procedures in the modified Thiel embalmed cadaver.

skin, they felt the fatty layer to be altered and liquefied. Some orthopedic surgeons felt that the tissue fluid was in excess and came in the way of their procedure especially spine surgery.

Mobility

The participants were of the opinion that the joint mobility was good.

Other Comments

The participants felt that the cadavers embalmed by the modified Thiel's method were excellent for learning purpose and surgical skills training in orthopedic procedures like arthroscopy.

DISCUSSION

Walter Thiel was a professor at the University of Graz, Austria who developed the embalming solution which would preserve the cadavers and retain the mobility and flexibility of the same. This has been extensively utilised by the European countries but very few institutions outside Europe are using it. The reasons could be many, primarily being awareness, where in the anatomists/surgeons working in various institutions are not aware of such a kind of embalming. Another reason could be the high cost of chemicals being used. This was brought out in a survey conducted on the awareness of Thiel embalming worldwide [5].

The Thiel embalmed cadavers retain the organoleptic properties such as softness and suppleness, mobile and flexible joints and tissues. Hence, the cadavers can be placed

in any position of choice as per the procedural requirement [Table/Fig-6]. This will facilitate the surgeon to practice any procedure as in living.

The surgeons who used cadavers embalmed by the Modified Thiel's method felt positive about its utility for their procedures. From [Table/Fig-3] it can be inferred that more than 80% of the responses for each of the criteria have been agreed upon. This demonstrates unanimously the modified embalmed cadavers can be used for surgical skill training except for a few shortcomings such as the denuded epithelium of skin and fragility of the tissue especially the viscera.

Colour

Usually formalin embalmed cadavers become dark in colour due to the effect of the chemicals. But in Thiel embalming, the epidermis gets peeled off and the skin appears white and pale [Table/Fig-6]. Most of the participants also felt the same as the colour of the cadavers were pale and hypo pigmented.

Odour

The odour of the thiel embalmed cadavers is sweetish and pleasant. Many participants commented the odour to be insignificant and not as irritating as with formalin embalmed cadavers. Some of the participants felt the odour was tolerable and was of fruity smell. This could be due to the alcohol base which gives it a fruity odour.

Consistency of Tissue/Flexibility of Joints

The tissue differentiation into layers, identification of structures, consistency of tissue was soft and natural. The participants were satisfied with the consistency and found the cadavers suitable for procedures like thyroidectomy, mastectomy, laparoscopy, arthroscopy and arthroplasty.

A study was conducted to check the quality of Thiel and formalin embalmed cadavers for thyroidectomy procedure. The participants concluded that the Thiel embalmed cadavers were realistic and suitable model when compared to formalin embalmed cadavers for general surgical procedures [6].

Some of the surgeons who tried GI anastomosis felt the tissue was very fragile and would give away when tried to check for the strength of the anastomosis.

The plastic surgeons were of the same opinion as the surgeons regarding identification and differentiation of layers. But they felt that the tissue was very lax and lost its turgor and hence was difficult to hold the tissues. The laxity of the tissues could be due to break down of the supporting fibres such as collagen due to the effect of chemicals such as boric acid.

The orthopedicians felt that the joints were mobile and they were suitable for procedures like arthroscopy and other orthopedic procedures. Few participants felt the tissue fluid was more than normal and this was continuously flowing as

the skin was incised and procedure conducted. The fluid could be due to liquefaction of the subcutaneous fat which is a common finding in Thiel embalmed cadavers.

A study was conducted using 30 Thiel embalmed cadavers for procedures related to oral surgery and implantology. It was concluded that the Thiel embalmed cadavers were ideal for teaching oral surgery related procedures as the techniques of suturing and drilling could be done as in fresh specimens [7].

The modified Thiel embalmed cadavers were most suitable for laparoscopy. Laparoscopic cholecystectomy, hysterectomy, colo-rectal anastomosis, hernia repair and assorted orthopaedic procedures have been tried and successfully done in workshops. Creating pneumoperitoneum is very easy in such embalmed cadavers. Because the viscera are soft and mobile, retraction of the various internal organs becomes easy and the target tissues are reached without much difficulty and the required procedure could be done.

A qualitative assessment of suitability of Thiel embalmed cadavers for laparoscopic renal resection training was conducted. The trainees and the faculty rated a 4/5 Likert scale and felt the experience on these cadavers to be as that in real life procedures [8].

A systematic review study of eight papers in order to describe the utility of cadavers for postgraduate surgical skill training. Thiel embalmed cadavers were used for laparoscopic training for colon, hernia and the participants showed high level of satisfaction for thiel embalmed cadavers as simulators. Thiel cadavers are of value when the consideration that the tissue feel in Thiel embalmed cadavers almost mimic real conditions [9].

The opinion of surgeons on the Thiel cadaver tissue in comparison to fresh tissues in terms of realism of tissue was well appreciated and was of statistical significance. According to the participants, the odour of the Thiel embalmed cadavers was of less concern. The Thiel embalmed tissue was considered realistic except for brain and eyes. The advantage of Thiel embalmed cadavers are visual and tactile realism, versatility as training tool and acceptable odour. The Thiel embalmed cadavers form a good simulator in comparison to formalin fixed cadavers especially for designing surgical skill training courses [10].

[Table/Fig-5] when analysed showed that most of the participants (87.03%) scored more than 75% on overall cadaver quality. The cadaver quality was graded between 51-64% by five participants as average cadaver quality. This was mainly by general surgeons who tried intestinal anastomosis. They felt that the tissue of the intestine was very fragile and gave away when they tried to test the strength of the anastomosis.

Taking all the above factors the participants unanimously felt the cadavers embalmed by the modified Thiel solution were suitable for surgical training and this could help them practice procedures, try new techniques and hone their skills before trying on the living.

A microscopic study of the muscle and tendon of Thiel embalmed cadavers was compared with that of formalin embalmed cadavers. This study revealed that the muscle proteins were disintegrated in Thiel embalmed cadavers whereas the muscle proteins were well preserved in formalin embalmed cadavers. This could be due to the effect of chemicals used in the embalming solution. This could also explain the rationale behind the flexibility of the joints and fragility of the tissues [11].

The brain tissue is not preserved in Thiel embalmed cadavers [5]. This could be because the chemical composition of the modified Thiel solution causes fat lysis. Whenever the cadaver tissue is cut open, there is an oily fluid which oozes out explaining fat lysis.

LIMITATION

This study is a perception study based on the opinion of the participants. The study also needs to look at higher levels of evaluation where in each procedure is evaluated under a set of criteria.

CONCLUSION

Thiel embalmed cadavers retain their organoleptic properties and hence facilitate surgical skills training. When compared to formalin embalmed cadavers, the modified Thiel embalmed cadavers are more realistic in experience while performing procedures by surgeons. The Thiel embalmed cadavers have been used for many procedures like thyroidectomy, mastectomy, laparoscopy, flaps, nasal endoscopy and have been found suitable for surgical skill training. The only hindrance in the usage of the modified Thiel embalmed cadavers by neurosurgeons is the brain related procedures, as the brain is not effectively embalmed and the high cost of chemicals involved in embalming the cadaver.

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ANNEXURE 1

S. No.	Criteria	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1	Colour is as in living tissue					
2	Consistency is similar to as in living tissue					
3	Odourless					
4	Layers can be differentiated well					
5	Approach to the area is good					
6	Mimicks live tissue					
7	The joint mobility was good					
8	Suitable for the procedure done					

[Annexure-1] Comments and suggestions for Improvement and the scoring for the parameters.

***Likert scale score:** Strongly agree- 5; Agree-4; Not Sure-3; Disagree-2; Strongly disagree-1.

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