Measuring the temperature of a simulated model of tissue during total joint arthroplasty

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***Abstract*— Infection after joint arthroplasty results in great discomfort and major financial expenses. The local wound temperature could influence the risk of infection. Laminar airflow (LAF) in the operating room (OR) has an effect on the wound temperature during surgery. The influence of LAF during joint arthroplasty is investigated by measuring the temperature of a tissue model with and without the presence of LAF using thermocouples (TC). The results show that the LAF lowers the median temperature of the tissue model by 1.85°C when the model is initially at body temperature. If this cooling effect also appears in human tissue, it is interesting to further explore the influence of temperature on the infection rate. Hence the possibility of measuring the wound temperature during a joint arthroplasty with an the infrared thermometer (IRT) and its practical implementation is also investigated. The accuracy and precision of the IRT are compared to those of the reference, the TC's. These experiments are conducted on the same model that is used to test the influence of the LAF. What can be concluded from the results is that the accuracy and precision of the IRT are too low. Therefore, the IRT is not suitable for wound temperature measurements during joint arthroplasty.**

I. Introduction

To minimize surgical site infection (SSI) due to microbes, LAF systems are used in the OR. The current line of thought is that these systems decrease contamination rates. Nevertheless recent studies have shown that the positive effects of LAF are questionable [1].

LAF is predominantly used during joint arthroplasty. The main reason for a failed joint arthroplasty is periprosthetic joint infection (PJI). Infection of a prosthetic joint occurs in 0.7% of all operations [2]. Although this percentage might seem small, the consequences are enormous. Infections lead to multiple operations, a longer period of disability and have a major financial impact. One study has estimated that the total cost of infection revision surgery in the US alone will exceed 1.62 billion USD in 2020 [3].

Infection is caused by external microorganisms, predominantly bacteria, that enter the body. The multiplication of these bacteria will ultimately lead to complications. LAF reduces 80% of pathogens in the air, but also influences the temperature in the OR as the flow has a temperature of 18°C.

The aim of this report is to investigate the influence LAF has on the tissue temperature. A lowered temperature negatively effects the immune system since the local immune respone is most effective in the range 35°C to 37°C [4]. Moreover this report explores the potential implementation of a non-invasive temperature measuring device during total joint arthroplasty. The implementation of this device is further evaluated by examining the influence of environmental conditions.

In order to achieve this, a tissue model is exposed to different circumstances and the temperature of the model is subsequently measured with both a TC and an IRT. The temperature progress for each situation is analyzed and the data is compared. This way a conclusion can be drawn about the effects of these conditions and if an IRT is a functional instrument to be used during surgery.

The hypothesis of the research states that the temperature of a representative model of a wound that is exposed to a cold LAF during total joint arthroplasty is lower in comparison with the temperature of the same model that is not exposed to LAF. Furthermore, the IRT approaches the temperature measurement of a TC with a maximum offset of ± 1°C in the OR. This value is based on the maximum allowed offset in which the temperature sensor is still of use according to an anesthesiologist from the Reinier de Graaf hospital (RdG). In addition the manufacturer of the IRT, Optris MS Pro, claims that the IRT has an offset of ± 1°C.

This paper consist of a literary research which provides relevant background information. Based on this research an experimental setup is determined. In *Methods & Materials* the measurement procedure and the procedure for data processing are explained. These results will be further analyzed in the *Results* and discussed in the *Discussion* to formulate an answer to the research question. Finally the conclusions are summarized and recommendations for future research are given in the *Conclusion*. This research study has been conducted as part of the Bachelor End Project for Mechanical Engineering students at the TU Delft in the third year of their Bachelor studies.

II. Literary research

Five years ago, RdG installed a new ventilation system, which facilitates distribution of clean air with a temperature of 18°C in the OR. Multiple studies [5] [6] and the World Health Organization [7] question the positive impact that different airflow systems in the OR have on deep SSI. Additionally the medical staff of RdG observed that the new ventilation system does not decrease the number of infected wounds after surgery.

Earlier research has proven that in 57% of all wound infections the clustered gram-positive cocci organisms are

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the cause [2]. This type of bacteria can be distinguished by the forming of clusters or chains. Gram-positive cocci can be distinguished by their ability to perform coagulase (enzyme that forms fibrin from fibrinogen) [8] and catalase (enzyme that decomposes hydrogen peroxide to water and oxygen) [9] reactions after 24 hours [10]. The optimal temperatures for the growth of these microorganisms lie in the range of 35°C to 37°C [11], similar to the optimal temperature for the immune system. An expected lower wound temperature decreases the local immune response, but it also creates sub optimal conditions for bacteria to grow. In RdG, the core temperature of patient is occasionally measured during surgery using an ear thermometer.

During total joint arthroplasty the protective layer, the skin, is broken. The tissue around the joint is normally not exposed to such circumstances. The tissue will lose heat through conduction as a consequence of contact with cold operating surfaces, evaporation of liquids, convection by exposure to the air and radiation through tissue loss. Hypothermia weakens the bodies natural immune system [4], stimulates the constriction of blood vessels, and causes a decrease in pressure of oxygen in the tissue which all together lowers the bodies natural resistance to bacterial infections. First of all, anesthesia lowers a patient's body temperature after an hour by 1.6°C ± 0.3°C [12], after which LAF causes an even faster decrease. A randomized clinical trial on wound temperature during open colon surgery showed a mean core temperature of 36.3°C, a mean wound temperature of 29.3°C and a mean wound edge temperature of 30.1°C [12]. This indicates that the local wound temperature instead of core temperature should be measured during surgery. The temperature of the open wound and the possibility to warm it during surgery are almost unexplored [13].

To investigate the open wound temperature, a minimal invasive technique for measuring temperature in the OR must be used. The IRT is increasingly taking its place in the medical world, as this instrument does not require contact with the object to be measured and can take discrete measurements. In 2015, a study [14] was done to measure skin temperature with a thermal camera of the lower abdomen. It was investigated whether image distance affects the measurement results. In this study three different distances were chosen, namely 300, 600 and 1000 mm. The results indicate that there are no significant differences in measured temperature at different image distances. Recent research [15] shows that Long wavelength Infrared Thermography (LWIT) sensors are very well capable of measuring wound temperature. During the study, the wound of a number of patients were photographed with a digital camera and analyzed with LWIT sensors. The LWIT sensor can detect temperature gradients between the wound and the skin around it. This research will therefore make use of an LWIT sensor to answer the research question.

Literary research has shown that the use of LAF is debatable, the aim of this report is to investigate the temperature effect that this LAF has on a tissue model. Tofu will be used as a simulated model. Research [16] confirmed that the tofu could be considered homogeneous in terms of heat transfer. Research has been conducted to acquire insights in thermal properties of tofu and its ability to mimic human tissue. Moreover the material is widely available, easy to shape and has a moisturized surface [17] [16].

III. Methods & Materials

A. Experimental setup

The same experimental setup as displayed schematically in Fig. 1 is used In every experiment. The main parts are the IRT, TC's, tofu, heat regulator and power supply. The experiments are conducted in an OR of RdG. Tofu is used to simulate tissue. A sample cutter, based on the principle of a cookie cutter, is fabricated to consistently shape the tofu to the desired size of 95x25x8 mm. The material structure of tofu can be described as moist and solid. The bottom side of the tofu is heated with the heat regulator to simulate the human body temperature. The temperature of the heat regulator is constantly measured with a TC type K. In Laboratory Virtual Instrument Engineering Workbench (LabVIEW) a control loop is designed to maintain a certain set temperature. Experiments have shown that a set temperature of 48°C will result in a temperature of 37°C in the tofu model.

Two electrically insulated TC's type K are used to measure the top surface temperature of the tofu. These TC's stay in the same position on the surface of the sample during all measurements, excluding the effects of misplacement of the TC's. The used type K TC's are capable of measuring temperatures in the range of -75°C to 250°C [18]. Every 214 ms a TC type K measurement is registered with an accuracy of ± 2.2°C or ± 0.75% [19].

A TC compares the voltage difference between the measuring junction and the cold junction compensation (CJC). The CJC is the reference environmental temperature [20]. TC's 1 and 2 (Fig. 1) are calibrated using ice point calibration [21]. Tap water is added to a bath of ice, after which the bath stabilizes around 0°C for approximately 15 minutes. This temperature is used as a reference temperature. The two TC's are placed in the water and the CJC value is adjusted to the point where both TC's indicate a temperature of 0°C. By using this method the CJC value in the OR is determined at 19.5°C.

For the temperature measurement in experiment 1 and 2 the IRT is mounted on a fixed location. The IRT has a Distance to Spot (D:S) ratio of 20:1. This is the diameter of the area being measured as it relates to the distance of the sensor. The IRT is placed on a distance of 150 mm. The used IRT is the Optris MS Pro, which operates in the range of -32°C to 760°C, with an accuracy of ± 1°C or ± 1% at $T \geq 20°C$ and an accuracy of ± 1.5°C or ± 1.5% at $0 \leq T < 20°C$. Every 300 ms an IRT measurement is registered [22].

To prevent inaccurate measurements the TC's are placed outside the area being measured by the IRT so that the TC's do not influence the IRT measurements.

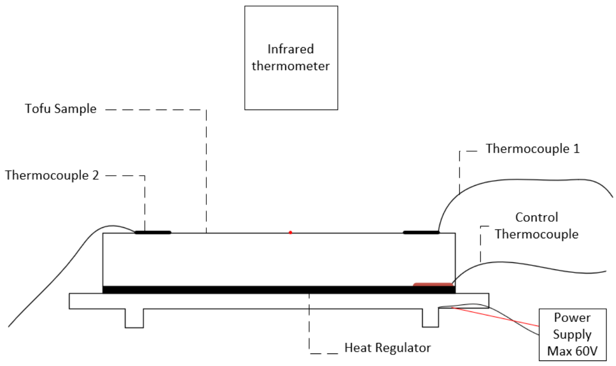

Fig. 1: Schematic overview of the experimental setup

The emissivity of tofu is determined by calibrating the IRT with a TC and the contact probe that is included with the Optris MS Pro. The emissivity is changed to a value where the IRT gives the same value as the probe and the TC. The emissivity value of 0.95 is used throughout this research.

Experiment 1 and 2 explore the utility of the IRT by analyzing the influence of the light in the ORs on the IRT and determining the accuracy and precision of the IRT. Experiment 3 examines the influence of LAF on the sample temperature. Each experiment is conducted five times. Pilot experiments have shown that a temperature gradient exists in the heating element and that this gradient is linearly distributed along the element. In all experiments the mean of the two TC measurements (T_{TC}) is considered as the reference temperature, as the TC's are calibrated using the ice point bath calibration. The reference temperature is stated in Eq. 1.

$$\overline{T}_{TC} = \frac{T_{TC1} + T_{TC2}}{2} \tag{1}$$

All experimental IRT measurements (T_{IR}) are compared to the reference temperature. The temperature difference between the IRT measurement and mean TC measurement is referred to as the offset ΔT in Eq. 2.

$$\Delta T = \mid T_{IR} - \overline{T}_{TC} \mid \tag{2}$$

The offset is used to determine the accuracy and the range of the offset to determine the precision of the IRT.

The TC's are connected to a computer through a Texas Instruments High Speed USB Carrier. The data of the TC's and the IRT of every experiment over a time interval $t_{total} = [0, 600]s$ are collected in LabVIEW and stored in a Microsoft Excel file. The temperature progress of each experiment is graphed and presented in the *Results*. This relatively long time interval t_{total} allows the temperature to reach a constant. Therefore the temperature progress and data of the sample at time interval $t_{stable} = [500, 600]s$ can be evaluated and compared with other measurement results. The evaluated data at the time interval t_{stable} is presented in the assigned tables. Relevant statistical parameters include the minimum and maximum temperature, median and range since the distribution of the data is asymmetrical. These values will provide an indication of the measured differences, accuracy and precision. The statistical significance of the results is determined by the Mann-Whitney U Test [23]. In the Mann-Whitney U test the null hypothesis H_0 stands for the difference of value between the samples is equal to 0. The alternative hypothesis H_a stands for the difference of value between the samples is different from 0. The alpha value will be set at 5% which results in a value of 0.05. If the p-value $>$ the alpha value then H_0 is accepted if not then H_a is accepted.

B. *Experiment 1*

Experimental question: What is the influence of light in the OR on the IRT measurement of the sample in comparison with a situation where an enclosure blocks the light from the sample?

Experimental setup: To examine the influence of light in the OR, the sample is placed on the heat regulator of the setup. In the OR two Dräger Polaris 600 operating lights are used. One light has 92 Light Emitting Diodes (LEDs) which altogether have a maximum light intensity of 160 000 lux. The ambient light intensity in the OR is 3 000 lux [24].

First the sample is exposed to the lights in the OR and the surface temperature is measured by both the IRT and the TC's. The enclosure, a cardboard box (485 x 325 x 380 mm), is opened on one side to expose the sample to the light in the OR and still block the LAF. Secondly the enclosure is closed to block the light in the OR and the temperature is registered again. All other factors are kept constant.

C. *Experiment 2*

Experimental question: What is the difference in temperature measurements with a TC versus an IRT?

Experimental setup: To explore the utility of the IRT during surgery the same setup is used as shown in Fig. 1. The accuracy is determined by calculating the difference between the IRT and the TC's, which will be referred to as the offset ΔT. To determine the precision the range in the offset will be calculated.

D. *Experiment 3*

Experimental question: What is the influence of LAF with flow conditions of T_{LAF}=18°C and a downward flow Q_{LAF} = 11.40 m^3/hr in the OR on the temperature of the tissue model?

Experimental setup: First the surface temperature of the tofu sample is measured without LAF ($T_{withoutLAF}$) using only TC's. To exclude the influence of LAF the enclosure is placed over the experimental setup. Next, the enclosure is removed, exposing the setup to LAF. The surface temperature of the sample ($T_{withLAF}$) is measured with the TC's. The settle temperature with and without LAF is measured, plotted and compared. The temperature difference between the measurements with and without LAF is called ΔT_{LAF} and is stated in Eq. 3.

$$\Delta T_{LAF} = |T_{withoutLAF} - T_{withLAF}| \tag{3}$$

IV. Results

A. Experiment 1

In Fig. 2 and Fig. 3 the temperature T_{IR} and $\overline{T}_{TC}$ of the sample with the light in the OR when exposed to light in the OR are plotted against time. In Fig. 4 and Fig. 5 the T_{IR} and $\overline{T}_{TC}$ of the sample without the light in the OR are plotted against time. All figures show a time interval $t_{total} = [0, 600]s$. The offset ΔT, defined in Eq. 2, for all five measurements is graphed in Fig. 6. For each measurement, minimum temperature, maximum temperature, median temperature and accompanying range over the time interval $t_{stable} = [500, 600]s$ is displayed. The results in Tab. III show an overall smaller offset ΔT of the experiment with light in the OR in comparison with the experiment without. The median offset with light in the OR for all data is 3.46°C, the median without light in the OR is 4.36°C. Tab. VIII shows that the difference in offset is 0.90°C. The accuracy of the IRT will be further discussed in the *Discussion*. As listed in Tab. III, the median range of experiment 1 with light in the OR is 0.5°C and the median range of the experiment without light in the OR is 0.18°C. Not only does light influence the offset but the IRT also shows more fluctuation.

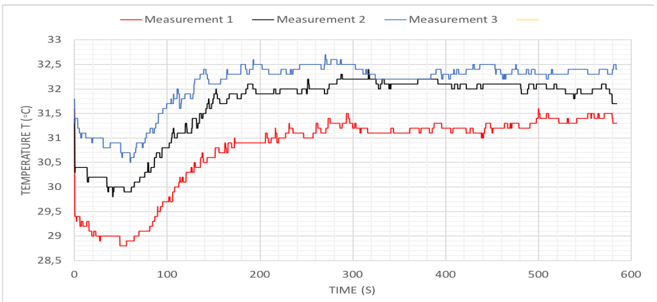

Fig. 2: Experiment 1: IRT temperature with light in the OR

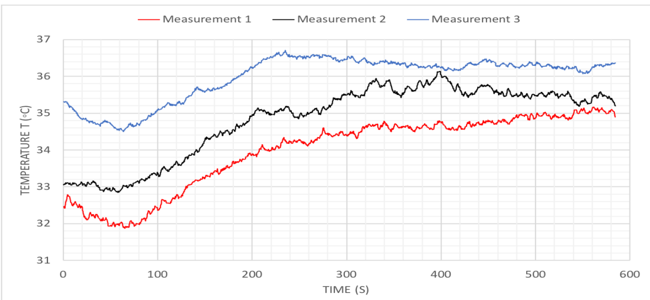

Fig. 3: Experiment 1: TC temperature with light in the OR

Measurement	With light in the OR 1 TC	 IRT	 2 TC	 IRT	 3 TC	 IRT
Min T (°C)	34.82	31.30	35.18	31.70	36.07	32.20
Max T (°C)	35.17	31.60	35.60	32.10	36.39	32.50
Median T (°C)	35.00	31.40	35.46	32.00	36.26	32.30
Range (°C)	0.35	0.30	0.42	0.40	0.32	0.30

TABLE I: Temperature evaluation of experiment 1 with light in the OR

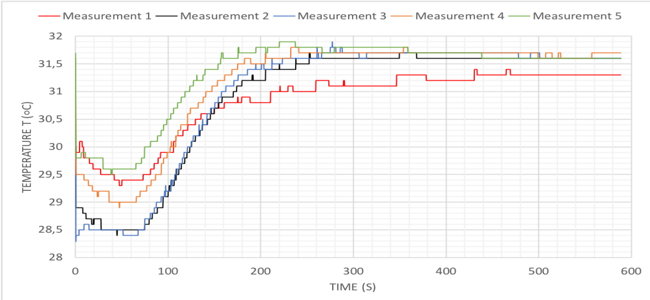

Fig. 4: Experiment 1: IRT temperature without light in the OR

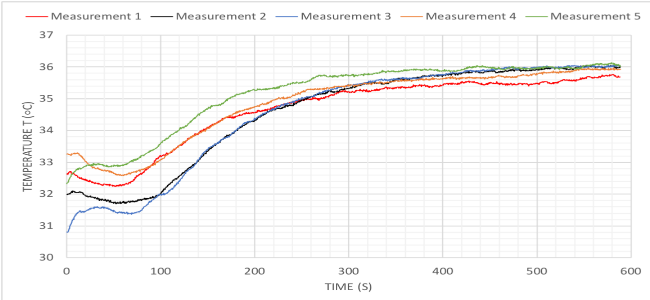

Fig. 5: Experiment 1: TC temperature without light in the OR

Measurement	Without light in the OR 1 TC	 IRT	 2 TC	 IRT	 3 TC	 IRT	 4 TC	 IRT	 5 TC	 IRT
Min T(°C)	35.45	31.30	35.90	31.60	35.96	31.60	35.77	31.60	35.92	31.60
Max T (°C)	35.77	31.30	36.05	31.60	36.07	31.70	35.97	31.70	36.13	31.60
Median T (°C)	35.60	31.30	35.98	31.60	36.01	31.60	35.90	31.60	36.01	31.60
Range (°C)	0.32	0.00	0.16	0.00	0.11	0.10	0.20	0.10	0.21	0.00

TABLE II: Temperature evaluation of experiment 1 without light in the OR

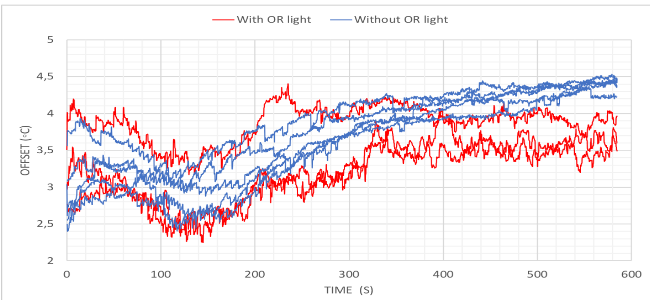

Fig. 6: Experiment 1: offset with/without light in the OR

	With light in the OR			Without light in the OR				
Measurement	**1**	**2**	**3**	**1**	**2**	**3**	**4**	**5**
Min ΔT **(°C)**	3.28	3.20	3.67	4.15	4.30	4.29	4.10	4.32
Max ΔT **(°C)**	3.81	3.70	4.09	4.47	4.45	4.47	4.37	4.53
Median ΔT **(°C)**	3.58	3.46	3.92	4.30	4.38	4.41	4.23	4.41
Range (°C)	0.53	0.50	0.42	0.32	0.16	0.18	0.27	0.21

TABLE III: Offset evaluation of experiment 1 with/without light in the OR

B. Experiment 2

In Fig. 4 and Fig. 5 T_{IR} and $\overline{T}_{TC}$ are graphed, respectively. The curves obtained for TC and IRT are similar in shape. The offset ΔT, defined in Eq. 2, is plotted against the time in Fig. 7. In Tab. IV data for the time interval $t_{stable} = [500, 600]s$ is presented. The median offset is 4.36°C and median range is 0.18°C, as can be seen in Tables IV and VIII.

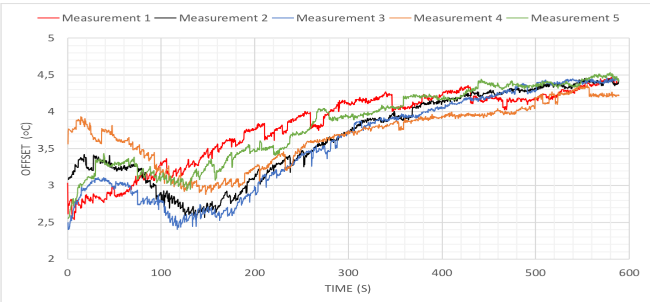

Fig. 7: Experiment 2: offset

	Offset				
Measurement	**1**	**2**	**3**	**4**	**5**
Min T (°C)	4.15	4.30	4.29	4.10	4.32
Max T (°C)	4.47	4.45	4.47	4.37	4.53
Median T (°C)	4.30	4.38	4.41	4.23	4.41
Range (°C)	0.32	0.16	0.18	0.27	0.21

TABLE IV: Temperature evaluation of experiment 2

C. Experiment 3

The temperature progress when the setup is exposed to LAF and the progress when not exposed, is shown in Fig. 8. The grouped results indicate a temperature difference, ΔT_{LAF}, between the experiment with and without LAF in the time interval $t_{stable} = [500, 600]s$. The corresponding data is presented in Tab. V and VI. In Tab. VII the minimum and maximum temperature of the measurements with and without LAF are presented. The experiment with LAF and the experiment without LAF both show left-skewed distributions. The difference in range is 0.18°C and the difference in median is 1.85°C.

	With LAF				
Measurement	**1**	**2**	**3**	**4**	**5**
Min T (°C)	34.18	34.01	33.31	33.30	31.79
Max T (°C)	34.36	34.18	33.43	33.46	31.98
Median T (°C)	34.29	34.10	33.35	33.37	31.90
Range (°C)	0.19	0.17	0.12	0.16	0.18

TABLE V: Temperature evaluation of experiment 3 with LAF

	Without LAF				
Measurement	**1**	**2**	**3**	**4**	**5**
Min T (°C)	35.45	35.90	35.96	35.77	35.92
Max T (°C)	35.77	36.05	36.07	35.97	36.13
Median T (°C)	35.60	35.98	36.01	35.90	36.01
Range (°C)	0.32	0.16	0.11	0.20	0.21

TABLE VI: Temperature evaluation of experiment 3 without LAF

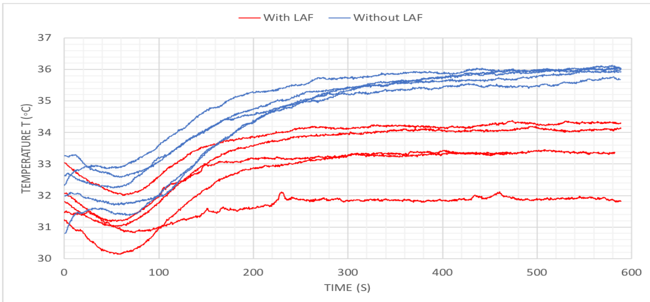

Fig. 8: Experiment 3: temperature with/without LAF

	Min	Max	Median	Range
T with LAF (°C)	33.30	34.36	34.11	1.06
T without LAF (°C)	35.45	36.13	35.96	0.68
Difference $\mid \Delta T_{LAF} \mid$ **(°C)**	2.15	1.77	1.85	2.83

TABLE VII: Temperature evaluation of experiment 3

D. Overview of all results

At last, the results of the three conducted experiments are summarized in Tab. VIII.

Exp.	Condition	Median TC	Median IRT	Offset
1	T with light in the OR (°C)	35.46	32.00	3.46
	T without light in the OR (°C)	35.96	31.60	4.36
2	T (°C)	35.96	31.60	4.36
3	T with LAF (°C)	34.11	-	-
	T without LAF (°C)	35.96	-	-

TABLE VIII: Data evaluation of all experiments

V. Discussion

This study shows that LAF influences the temperature of a tissue model.

Different moisture conditions could influence the decrease in temperature and therefore the temperature difference could be higher than 1.85°C. Also, the Optris MS Pro IRT is not a suitable device for measuring the local wound temperature during total joint arthroplasty. The results indicate poor similarity between the TC and IRT. Structurally, The IRT measures a lower temperature of the model. The light in the OR influences the precision of the IRT. The accuracy is questionable because the offset differs greatly and is larger than ± 1°C. The sections below elaborate on the setup and each experiment separately.

A. Experimental setup

The final setup eliminates most sources of disturbances. Experiments which were executed incorrectly were removed from the data.

The common perception is that a type T TC is more accurate than type K [25]. Nevertheless conduction along the leads of the wire of the TC could undesirably influence the outcome. The TC's are attached to the sample surface and the conduction could be influenced by the temperature of the air. Since type K TC wires have a lower thermal conductivity compared to type T TC, the usage of type K minimizes the influence of the air temperature on the surface measurement and therefore results in less measurement error [26].

All measurements have a p-value < 0.0001. As the computed p-value is lower than the significance level alpha = 0.05 one should reject the null hypothesis H_0, and accept the alternative hypothesis H_a.

B. Experiment 1

The Mann-Whitney U Test proves that the measurements with the light in the OR are significantly different from the measurements without light in the OR. From the results can be concluded that the offset ΔT when the sample is the exposed to light in the OR is less than the offset when not exposed. Intuitively a smaller offset is expected when the sample is placed within the enclosure. However Fig. 6 shows that the IRT structurally underestimates the temperature of the sample in comparison with the TC's. When the sample is not covered, ambient IR light is measured by the IRT which results in a higher temperature reading. Because of this higher temperature reading the measurement value will be closer to the reference value resulting in a smaller offset. The finding that this offset is smaller does not mean that the IRT functions better under these circumstances. The Dräger Polaris 600 operating light is used in cold mode, which means that no infrared radiation is emitted by the LEDs [27]. However IR wavelengths from other light sources and objects that emit IR radiation present in the OR disturb the measurement. The external radiation of IR causes an increased fluctuation in the accuracy of the IRT. The range of the enclosed IRT is smaller than the range of the IRT when exposed to external radiation, see Tab. III. This indicates a better precision with enclosure.

After experiment 1 with light in the OR was conducted three times, the operation room was needed. Therefore, more measurements could not be conducted. It is concluded that the performed measurements already represent the thermal progress of the model exposed to external lighting properly.

C. Experiment 2

The Mann-Whitney U Test proves that the measurements with IRT are significantly different from the measurements done with the TC's.

Fig. 7 shows inconsistency in the offset. The results present in Tab. IV differ between 4.10°C and 4.53°C. The offset is not equal to the value of ± 1°C as stated in the subhypotheses. A study conducted by Michalski et al [28] states that ΔT between the reference value and experimental value is 1.5°C at maximum. This means that an offset of ± 1°C might not be attainable. Nevertheless, the obtained offset in the IRT is still significantly larger than 1.5°C.

An IRT is influenced by many factors. The most important factors are the emissivity, moisture of the object, sensor distance , angle of observation, air supply and at last the effect of the sources of interference such as the heat produced by the heating elements or by the lamps lighting the surface [28]. Calibration of the IRT and the test setup excludes most of these factors. One of the limitations is the lack of knowledge of the emissivity of moist tofu surface. During calibration of the IRT the emissivity changed with temperature. The value of 0.95 was found in most, but not all calibration measurements at a sample temperature of 37°C. To test the influence of moisture on the emissivity of the IRT, the emissivity of other materials such as the ceramic iron heating element, a piece of white paper and an assumed black body were calibrated and compared with known values. The emissivity still fluctuated with different temperatures. The Optris MS Pro IRT is therefore not a suitable device for measurements on the model.

The findings of this report regarding the difference between conductive and IR devices contradict some past researches [29][30] although more recent studies supports the conclusion of this report [31][32].

D. Experiment 3

The Mann-Whitney U Test proves that the measurements with LAF are significantly different from the measurements without LAF. The temperature progress as displayed in Fig. 8 and the data in Tab. VII show a higher settle temperature when the sample is exposed to LAF. For the data in Tab. VII, measurement 5 is eliminated to exclude an error caused by the introduction of a new sample whilst all other measurements were conducted with the same sample. The limitation of this method is that the multiple heat and cool down cycles will cause changes in moisture content of the sample. The influence of LAF decreases with every measurement, as the maximum and minimum temperatures for measurement 1-5 in Tab. V indicates. It was determined that the influence of the misplacement of the TC's is greater than the influence of the difference in moisture content. To maintain similar conditions throughout all experiments, the sample is not replaced after every measurement.

Furthermore, during total knee arthroplasty the wound is rinsed with water two times and rinsed with disinfectant liquid once. The rinsing moisturizes and cools down the wound even further. The tofu temperature is regulated by a heat regulator during the measurements. In human tissue the wound temperature is regulated by the blood flow. The blood flow heats the wound more uniformly and possibly results in a different temperature distribution than the model. Therefore it is interesting to investigate the temperature progress in human tissue. The assumption is made that lower temperature will increase the chances of infection, because local hypothermia commonly leads to an increased infection chance [33].

VI. Conclusion

The initially stated aim of this research was to identify the influence of LAF on the temperature of a tissue model and to explore the possibilities to perform discrete measurements with an IRT. While recognizing the limitations of the set up, the conclusion can be drawn that the IRT is not suitable to use during joint arthroplasty. Therefore in future research on non-invasive measurements, the implementation of different IRT should be explored. The research has furthermore concluded that the IRT experiences negative influence from ambient lighting. In further research an IRT should be used with an enclosure to minimize the effects of ambient light. The temperature with LAF is substantially lower than without LAF. The influence of wound temperature on infection rate is still undiscovered. This research has demonstrated the relevance of investigating the effect LAF has on human tissue. Because all the experiments are conducted on a tissue model and not on human tissue, further research will have to explore the effect of LAF on the human body during joint arthroplasty.

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