TRAVAIL DE MASTER MMED:

Measurement of prehension force during a microsurgical gesture: a pilot study.

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TABLE DES MATIERES

1. INTRODUCTION:

During the last decades and still nowadays the practical teaching of surgical residents was only evaluated, guided and taught through the expertise of a senior surgeon, which is highly subjective and unequal between experts (Ramachandran, 2013). This training based on the Halstedian model depended on the opportunities and relationship the residents build with their mentor and could lead to an unfair and heterogeneous training. Consequently, only little objectives elements is known about what makes a surgical gesture optimal. Indeed, the resident performs and modifies his/her gesture as taught by his mentor. No objective technique, data or knowledge underlie his/her new learning to ensure him/her that the applied gesture is the best. Another issue brought by the Halstedian model is that a lot of what improves a surgeon's gesture (e.g the pressure applied on the clamps, muscle activity, etc) cannot be assessed by direct observation.
However, these last few years, more objective types of assessments have been studied to fill the lack of objective and updated training. Most of the recent studies focus on a few data, such as width of movement and time, but none have been interested by other data such as cerebral activity or muscular activity. Nevertheless, no study has yet compared measurements to find out which parameter is the most discriminative, nor the most efficient to use in pedagogical tools.

The aim of this pilot project has been to create a microsurgery-connected clamp enabling to measure the prehension force during a microsurgical gesture and to compare it according to the subject experience (expert, intermediate, novice).

The survey of the literature on the analysis of the hand motion during the learning of a microsurgical gesture revealed that only a few articles are dealing with the subject.
The review results show that despite the different movements analysed, three main quantitative detection instruments have been validated:

1) ISCAD, passive cinematic optoelectronic cinematic system, automatic tracking) (Datta, 2012) (Grober 2003):

Most of the studies have validated the ISCAD (Imperial College Surgical Assessment Device). The latter consists in two electromagnetic sensors placed on the dorsal face of the distal interphalangial joint of each hand. ISCAD measures the movement of the hand through three variables: total time, path length and number of movements. Even though a strict protocol should be applied to ensure the data transposition, we can see through those studies that there isn't any consensus on the method for using the ISCAD. For example, two studies didn't place the detector on the same localisation: one placed it on the dorsal face of the hand (V. Datta, 2012) as the other on the distal interphalangial joint (G-M. Saleh, 2006). This change can question the validity of the data.A similar system was also used: Patriot3-dimensional hand motion tracking.

2) Automatic tracking (Mcgoldrick, 2015):

This system uses a computer model, that doesn't require placing a detector on the surgeon's hand but follows an object of interest on video footage. This was only used in one study reviewed: Motion Analysis for Microsurgical Training: Objective Measures of Dexterity, Economy of Movement, and Ability (McGoldrick 2015). The system provides four variables analysis: time, tremor, extreme movements, and overall pattern of movement composite score. This system has the benefit of being captor free and based only on video footage, which can easily be used into the theatre.

3) System optoelectronic cinematic passive (Saleh, 2008):

This system is formed by four reflective markers placed on both hands between the second and third metacarpal and in the middle of the middle phalanx of the index, which are detected by cameras placed at 360° around the subject's hands. The combinations of each camera detections can be gathered in a computer program to plot a 3D movement. This system has been used in one study only: Effects of habitual physical activity on microsurgical performance (Omran 2016). Unfortunately, this study doesn't precise the variables they are recording through this system.

A qualitative scale (OSATS) (Erza, 2009) has also been validated. Once validated, this scale has been used as a standard to validate other instruments. This scale is used for expert surgeons to assess the performances of a resident. The OSATS is based on 7 characteristics, which can be rated from 1 to 5. Even if this scale has been validated, it's still depending on the appreciation of a surgeon, which can be subjective. To lower this, the analysis can be made on video by two blinded surgeons.

One study (Harda, 2015) used a connected needle holder to calculate the force applied on it. It was used to compare the force applied on the clamp at specific steps such as needle gripping, needle extraction ect. It could calculate a force up to 5N thanks to gauges place at the top of the needle holder jaws. The study showed that the maximal force was greater in surgical resident than experts. As they broke the gesture in steps that resident didn't pass distinctly and that a great part of their data couldn't be used, some of their finding were as robust as expected.

As said before, according to (Saleh, 2008) and (Harada, 2015), 3D optoelectronic chamber can be used to follow the movements of a surgeon hand by calculating, among others, the path length, the number of movements and the time taken for the task. The optoelectronic tracking system has been used with different techniques. Indeed, in the Mc.Beth (2017), the markers are placed on the top of the instruments. However, in the Saleh (2008) they were placed on the surgeon's hand. As our pilot study aims to compare measurements, it would be appropriate to analyse both hand and instrument movements, as these methods have already been validated by different studies (Mc. Beth, 2017) (Saleh, 2008). This analysis will help us understand the chronology of the learning of microsurgical gesture. Indeed, as the studies never did a comparison between hand and instruments movements, we don't know if the novice surgeon starts having more efficient hand movements that leads to a better control of the instruments, or if he does first improve the movement of the instruments.

The analysis of the different protocols showed that the studies analysed involved a median number of 30 participants, equally split in three or two different groups of experience: novice, intermediate, expert. The different categories of expertise are based on three main axes, each adapted to the surgical specialty or the study setting:

1) the level of study of the subject: Omran (2016), Vivek Datta (2012), Mcgoldrick (2015), Harda (2015), Moulton (2006). For example, were enroll as novice: medical student and post-graduates trainees (Omran 2016), postgraduate year 1 and 3 (Moulton, 2006) as experts microsurgery tutors (Omran, 2016)

2) the number of the interest's gesture performed: Saleh (2006), Erza (2009), Grober (2010), Rodrigez (2016); (e.g. corneal suture: less than 5 for novice, between 5-100 for intermediates and more than 100 for experts (Saleh 2006))
3) the number of surgeries performed Harda (2015) Saleh (2008), Grober (2003). (eg. bypass surgical volume in the past year (Harda, 2015)
We can emphasis that the number of participants varies substantially from 2 (Grober, 2010) to 90 (Grober, 2003). .
The studies reviewed also showed the importance of a strict gesture's protocol. As raised in the Moulton study (2006), the simpler or well broke down the gesture is, the more relevant the data will be. Accordingly, most of the studies limited the gesture to an end-to-end vascular anastomosis: Rodrigez (2016), Harda (2015), Mcgoldrick (2015), Omran (2016), Prunieres (2014). Other studies have focused their analysis on more specific gestures such as corneal stitches Erza (2009) or a vasectomy Grober (2010).
However, as Harda highlighted: "data {…} (might be) invalidated because the artificial blood vessels {…} (can be) very fragile and easily torn {...} (Harda, 2015)". To add to this example, the Konnyaku Shirataki noodle has not been validated (Prunieres, 2014). However, the penrose drain has been successfully used in different studies such as Grober (2003) and Moulton (2006). Other more specific models have been used in ophthalmology in order to respond to the need of corneal surgery (Erza, 2009). Mcgoldrick (2015), Rodriguez (2016) used a non-living chicken model, on which novice surgeons have been able to perform an end-to-end anastomosis. This model also offers the possibility of patency measurement (Rodriguez, 2016), which is an important qualitative data for vascular surgery.
To add more precision on the protocols, most of the studies used a 9-0 or 10-0 nylon for the stiches: Prunieres (2014), Saleh (2006), Grober (2003), Erza (2009), Grober (2010) And Mcgoldrick (2015). We can also highlight the fact that some of the studies failed to give a complete protocol in their abstract such as Omran (2016), where no detail regarding the materials or the type of measurements were given.

2. MATERIAL AND METHODS

The study protocol is based on 6 elements: the subjects (2.1), the microscope (2.2) under which the gesture has been performed, the sutures used (2.3), the tissue (2.4), the gesture itself (2.5) and the connected clamp along with the other instruments (2.6).

2.1 THE SUBJECTS

All our subjects were enrolled either in the hand surgery ward or the medical faculty of Lausanne.

Regarding the categories, we will follow the example of Rodrigez(2016) and Saleh (2006) among others, with three categories (novice-intermediate-expert) in order to have a better picture of the learning curves that we intend to find in the main study. They have been subdivided in three main categories of experience based on their title in the CHUV and the number of years they have been practicing microsurgery or medicine. Each category included at least 4 participants.

They are all aged between 18-60 years old, two left-handed, eleven right-handed. Were enrolled 6 men and 7 women.

The inclusive criterion was having no medical condition modifying his/her ability to perform a precise gesture of the upper limb.

THE NOVICE CATEGORY

This category was formed by four medical students (three women, one man) with no microsurgical experience, and even more for two of them no suture experience at all. The additional inclusive criteria were to be a 6th year medical student at UNIL, having no microsurgical experience and successfully perform the knot tying in macro.

One of the medical student was left-handed, the other three right-handed.

THE INTERMEDIATE CATEGORY

This category was formed by five interns (four women, one man) with at least two years of medical experience but no specialist degree. All the intermediates were right handed. As the people involved in the study had very different profiles, we decided to subdivide into two categories of experience: novice-intermediate (two women) and intermediate (two women and one man). Even though it will reduce the number of participants to two per categories, as the data might be too divergent inside the category, the robustness of the data will be ensured by that split.

The additional inclusive criterion for novice-intermediate: at least two years of medical experience but none in microsurgery.

The additional inclusive criterion for intermediate: at least 6 months of microsurgical residency but no specialist degree.

THE EXPERT CATEGORY

The expert was formed by four residents (four men), three right-handed and one left handed. The additional criterion was to have an FMH specialist degree in a microsurgical specialty such as plastic surgery or hand surgery.

2.2 THE SUTURE

We chose a dafilon 10-0 DRm 4 black. This suture is made of polyamide, is non resorbable. The needle is 3/8 of a circle (135°) and 70µ width.

This suture is commonly used for microsurgical intervention such as nerve or vessel anastomosis.

2.3 THE MICROSCOPE

The microscope is a Zeiss OPMI 111. This microscope was used during neurosurgery at the CHUV. In a preliminary session we decided to use a 7.5x magnification in order to be able to perform correctly the gesture. The participants were then able to adjust the microscope to their vision by pulling it upwards or downwards.

2.4 THE TISSUE

The chosen tissue was a chicken wing as it contains two easily dissectible vein. Another advantage of this tissue is that, as the wings themselves have roughly the same calibre, the veins are also similar from a wing to another ensuring to reproducibility of the experience. Moreover, this vein has a very similar diameter from the veins found in the human.

2.5 THE INSTRUMENTS

The instruments that have been used are the same as in microsurgeries at the CHUV. The participants used forceps and a connected needle holder.

The forceps are a classical Jeweler's forceps used in microsurgery. The participants used it to manipulate the tissue directly.

2.5.1 THE CONNECTED CLAMP

The connected needle holder was created especially for this study to allow us to measure the force applied on the needle and the tissue. It was created on an existent needle holder the model FD241R from Aesculap, Bbraun.

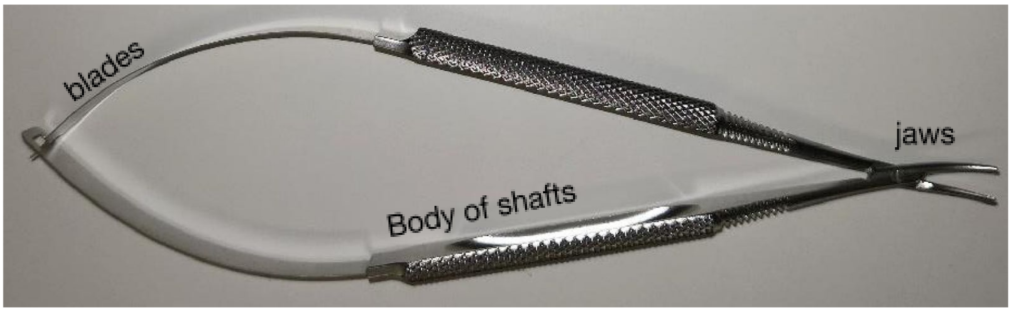

Figure - Needle holder parts (source: Travail de bachelor Antoine Nogueira HEIG-VD modified by Justine Lattion)

As the force can be infer from deformation of a mass, a study of the needle holder statics has been performed. Nogueira found that there are two steps during the deformation of the needle holder shafts. First only the blades support an elastic deformation. Then, once the jaws are closed, the shaft of body also support an elastic deformation. The point of maximal deformation was found at the screw.

To be the most accurate, the gauges have to be place close to the point of maximal deformation. Therefore, they've been place at the base of the two shafts of body. The needle holder has been modified by the adjunction of 8 gauges (4x HBM, 1-LY11-0,3/120, 4x HBM, 1-LY13/120) which can measure a force up to 50N every 0.025 second. Since the removal of matter modifies greatly the statics of the needle holder, four gauges (HBM, 1-LY11-0,3/120) have been placed on the exterior part of the end of the body's shafts perpendicular to one another and four (HBM, 1-LY13/120) on the interior and exterior of the blades (Figure 62,68,69). To stabilise the gauges on the clamp, a glue (HBM, X60) with no viscoelastic deformity has been used.

Figure 1- localisation of the internal distal gauge (source: Travail de bachelor Antoine Nogueira HEIG-VD)

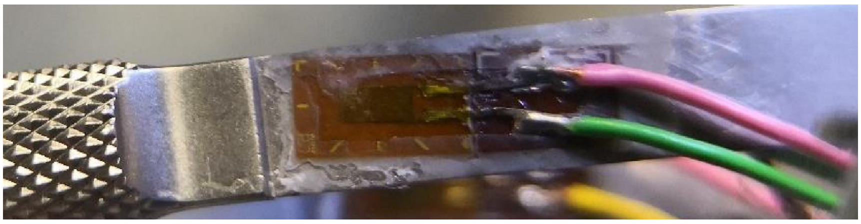

Figure 2- localisation of the external distal gauge (source: Travail de bachelor Antoine Nogueira HEIG-VD)

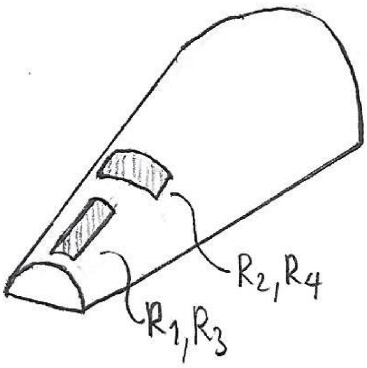

Figure 3- localisation of the proximal gauges (source: Travail de bachelor Antoine Nogueira HEIG-VD)

In order to be the most cost effective, simple pushbutton swift gauges have been chosen. They have the advantage of being very easy to use and very cheap. However, as the variation of resistance from only one gauge is too low to be measured, two opposite gauges have been connected with a Wheatstone bridge.

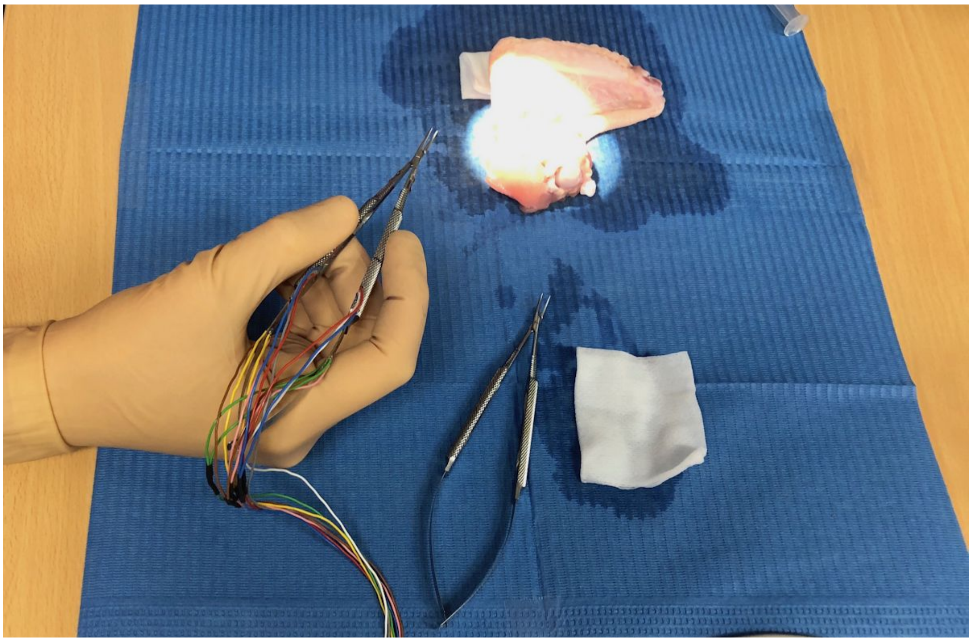

Figure 4- novice 1 with holding the connected clamp

A software was designed to directly visualise the force profile. The interface was created on three levels: jaws open, jaws closed and the shafts of body touching. These three levels were divided by two baselines: 0.8N the minimal force needed to close the two jaws and 13N the minimal force for the two shafts of body touching.

2.6 THE GESTURE[1]

The most important element for the gesture was a strict protocol to ensure the reproducibility in between participants. Therefore, we decided based on MOULTON (2006) results, to limit the gesture to a simple microsurgical knot on a vessel.

The restricted visual field under the microscope prevents the surgeon to cross the hands. Therefore, the technique is slightly different. The gesture has been divided in 7 steps.

1) Take the needle 1/3 proximal part at an 90° angle with the needle holder

2) Open the vessel with the forceps and pass the needle through the first vessel wall. Release the needle.

3) Take the needle as in (1). Hold the second vessel wall with the forceps and pass the needle through the second wall.

4) Perform the flat double knot by forming two loops around the forceps with the needle holder and then pull the two instruments outwards.

5) For the first simple knot, form a loop with the forceps on the needle.

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[1] *Participant information sheet can be found as annexe 3*

6) For the second simple knot, perform the loop on the opposite instrument.

7) Cut the two ends of the suture.

The novices were given a 1h teaching with a macro-demonstration and they received a document[2] with sketches, videos and texts explaining the knot tying protocol.

The novice-intermediates were given only a macro-demonstration.

The intermediates and the experts were given an oral instruction.

2.7 DATA ANALYSIS

DATA COLLECTION:

The results were the raw data of every force measured by the connected clamp. Thanks to Microsoft Excel and MATLAB software, those data were analysed by group of experience.

The connected clamp software was designed to create automatically an excel sheet with all the force measured during one experience. The force is measured 1/0.025 second and at a precision of 1 millinewton. The time can be calculated from the number of measurement done per experience.

DATA CHOICE:

This pilot study had two goals: to validate the Nogueira connected clamp and to found out which data collected is the most discriminative. We based our choice of measurement to analysis on the pression profiles because it varies on:

- Force
- Time
- Amplitude

There for, we based our analysis on six measurements:

- Maximal force, minimal force and mean force in order to analyse every aspect of the change in force
- Time
- Standard derivation as it a statistical measurement of a sample dispersion

STATISTICAL ANALYSIS:

Z-tests have been performed on every measurement to ensure the statistical significance between the expert/intermediate, intermediate-novice/intermediate, novice-intermediate/novice. To build these z-test we based our H0: $\mu = 0$, therefore, if H1

[2] *The documentation can be found in annexe 2*

was rejected, then the data were statistically different. However, as our sample contain only two to four participants in each categories, the statistical analysis can not be performed. Therefore, the Z-test is only an estimation for further study.

3. RESULTS

3.1 PRESSURE PROFILE (PP)

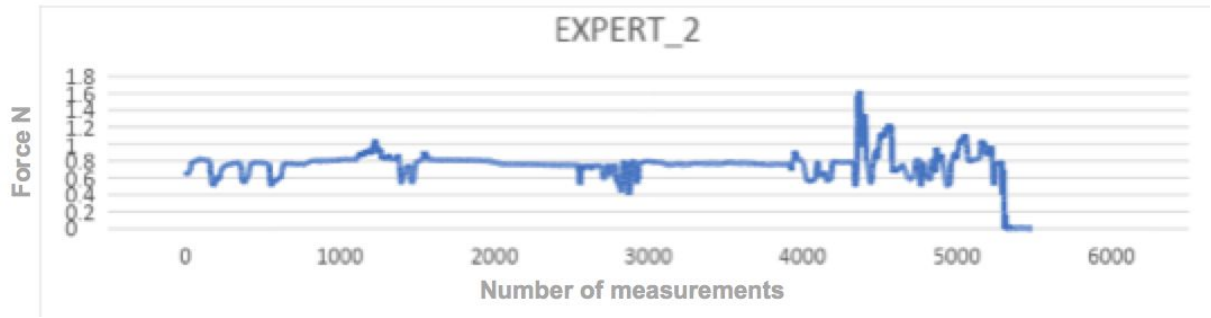

Figure 5- expert_2 pressure profile

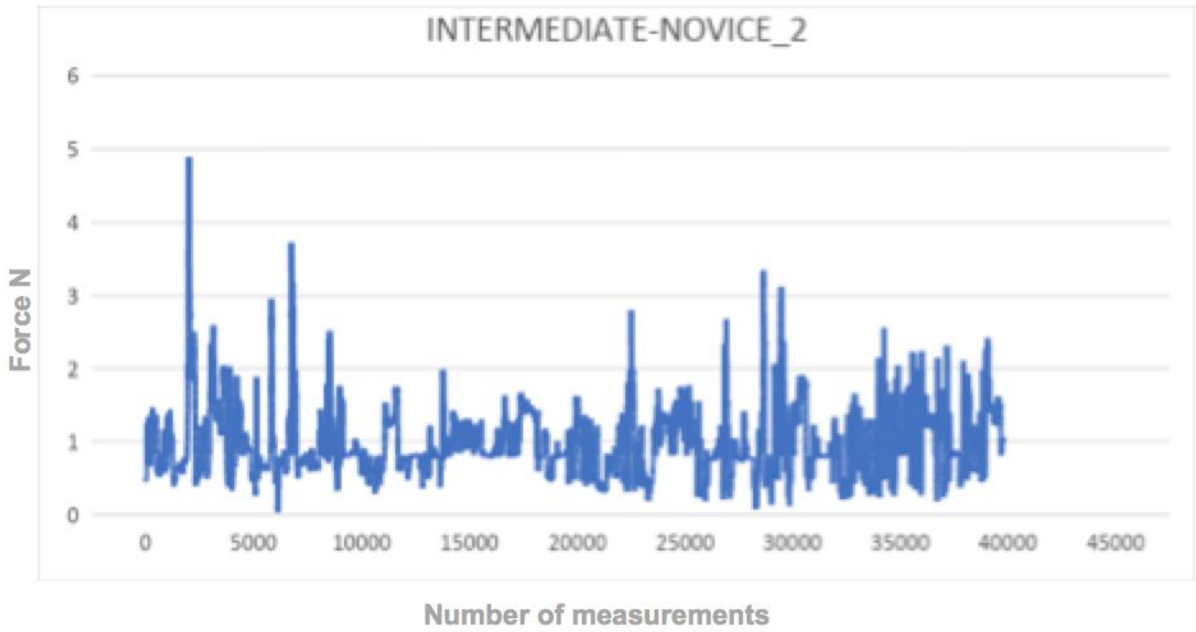

Figure 6- Intermediate-novice_2 pressure profile

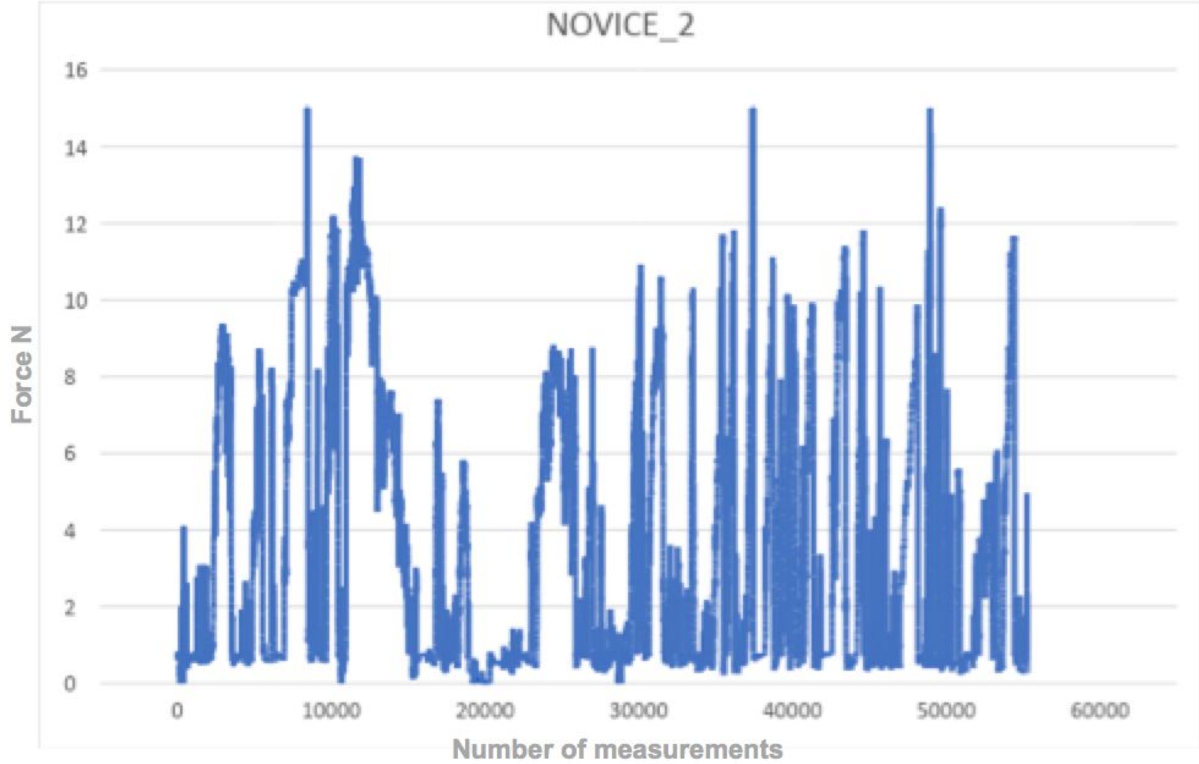

Figure 7- novice_2 pressure profile

3.2 MAXIMAL FORCE (MF)

Table 1 – Maximal Force

	Min MF [N]	**Max MF [N]**	**Mean MF [N]**	**Variance MF [N]**
Novice	4.5	15	11.73	19.9
Novice-intermediate	4.9	7.7	6.28	3.9
Intermediate	2.205	3.049	2.75	0.3
Experts	1.6	3.5	2.39	0.9

3.3 MINIMAL FORCE (mF)

Table 2 – Minimal Force

	Min mF [N]	Max mF [N]	Mean mF [N]	Variance mF [N]
Novice	0	0	0	19.9
Novice-intermediate	0	0.035	0.0175	3.9
Intermediate	0	0.019	0.0064	0.3
Experts	0	0	0	0.9

3.4 MEAN FORCE (µF)

Table 3 – Mean Force

	Min µF [N]	Max µF [N]	Mean µF [N]	Variance µF [N]
Novice	1.01	3.381	2.5	1.02
Novice-intermediate	0,94	1.62	1.3	0.23
Intermediate	0,79	1.20	1.1	0.04
Experts	0,68	0.91	0.8	0.015

3.5 TIME (T)

Table 4 - Time

	Min T [min]	Max T [min]	Mean T [min]	Variance T [min]
Novice	23.04	29.43	25.3816667	12.41
Novice-intermediate	8.71	16.57	12.6446	30.81
Intermediate	2.03	4.38	2.83333	0.059
Experts	2.3	2.8	2.5406	0.085

3.6 STANDARD DEVIATION PARAMETER (SDP)

Table 5 - Standard Deviation

	Min SDP [N]	Max SDP [N]	Mean SDP [N]	Variance SDP [N]
Novice	0.8	3.6	2.1	1.46
Novice-intermediate	0.4	1.5	0.9	0.57
Intermediate	0.27	0.75	0.5	0.06
Experts	0.18	0.45	0.3	0.08

3.7 SUMMARY FIGURE

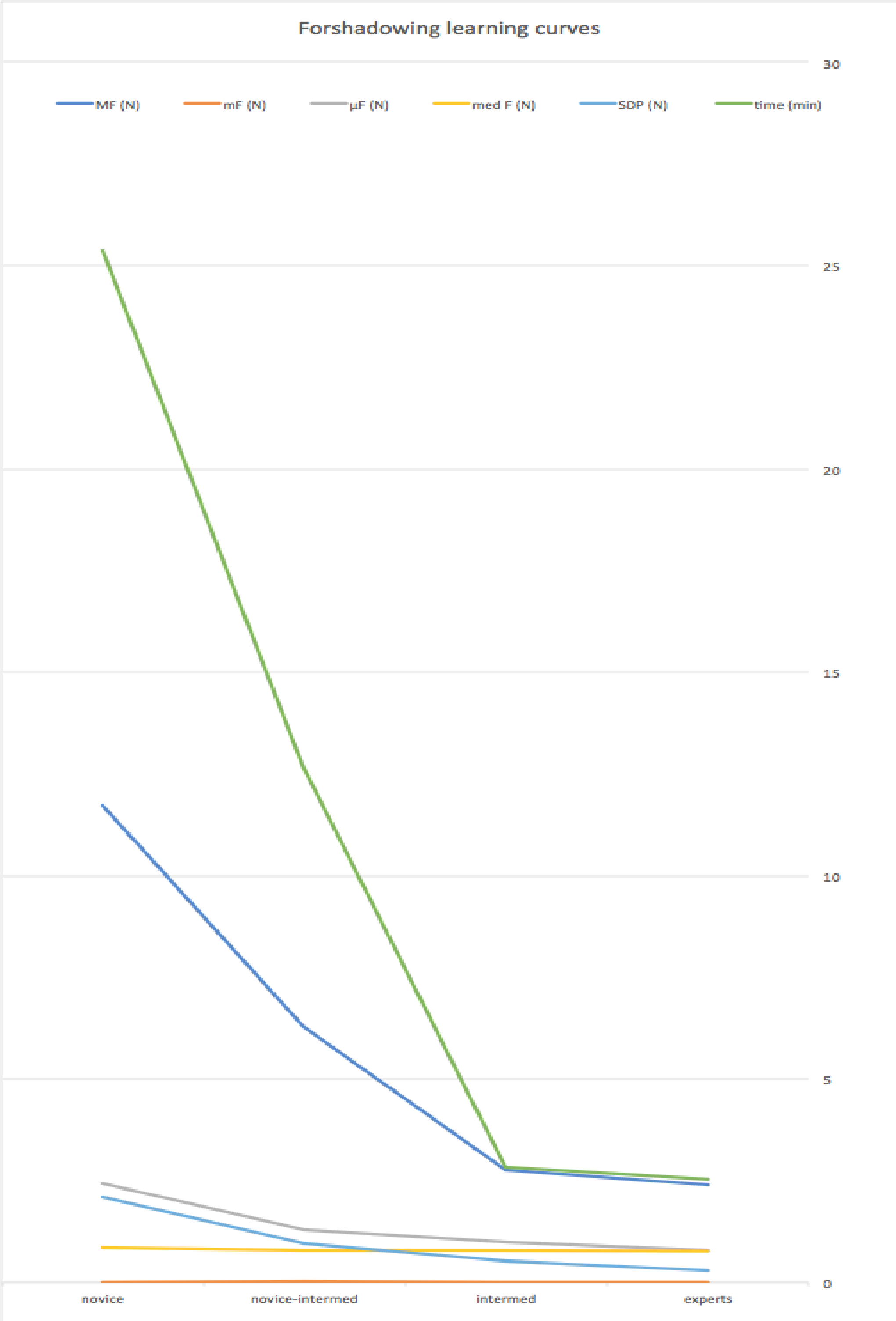

Figure 8- Approximative learning curves

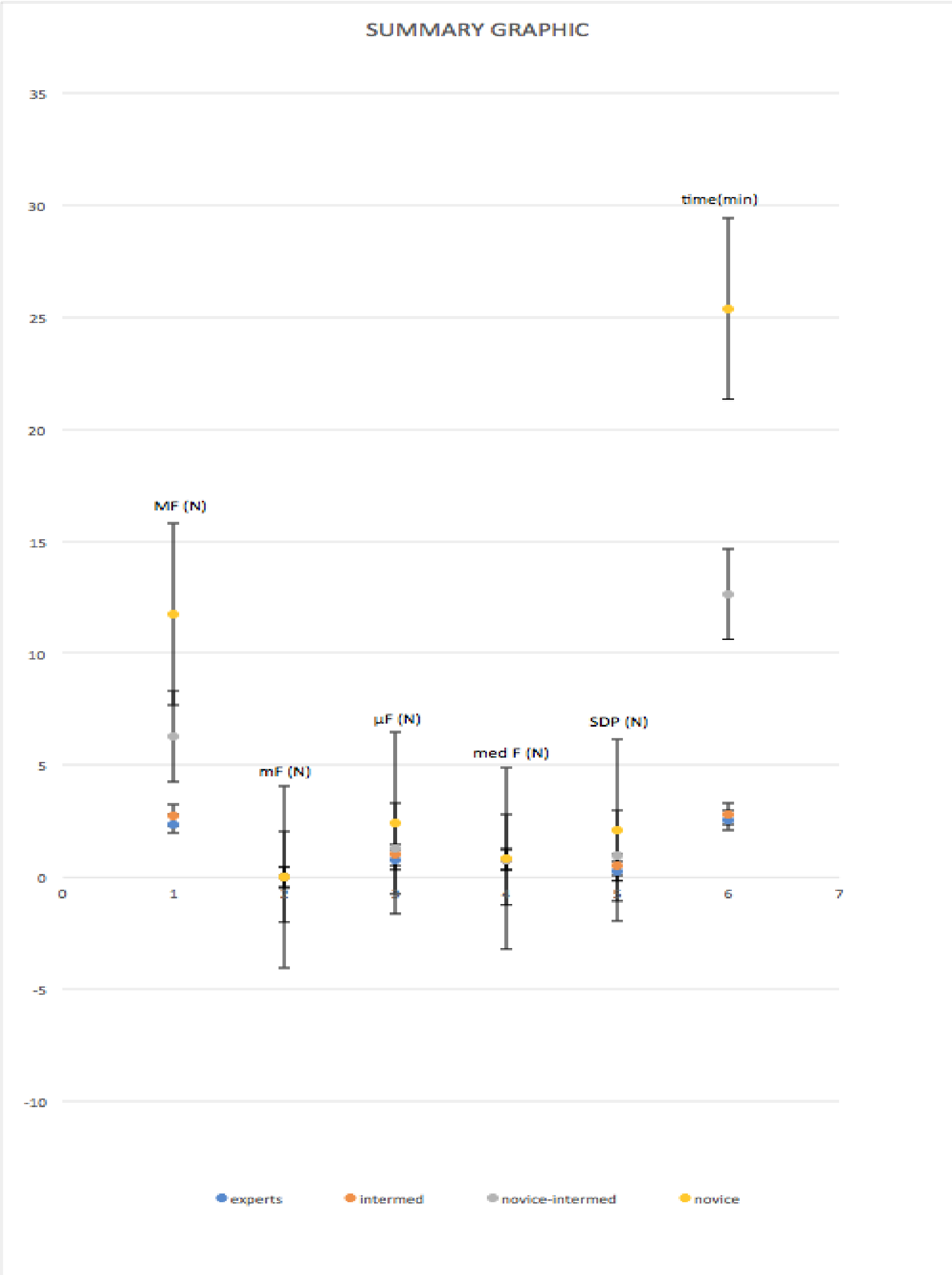

Figure 9- summary of results

3.8 Z-TESTS

Only a summary of the Z-test results is presented here. The details of the z-tests can be found in annexe 3

	Expert/intermediate	Intermediate/ Intermediate-novice	Intermediate-novice/ novice
P value MF α = 0.05	0.469402	0.126366	0.038066
P value mF α = 0.05	0.162755	0.372878	0.327360
P value μF α = 0.05	0.327743	0.473321	0.024783
P value Time α = 0.05	0.25785	0.008817	0.050466
P value SDP α = 0.05	0.290623	0.498517	0.077438

Figure 10- P value from the Z-tests

4. DISCUSSION

4.1 RESULTS

The minimal force has not been shown to correlate with hand dexterity as most of the participant opened completely the clamps and therefore applied no force on it. The smallest minimal force was 0 for most of the participants, the maximal was: 0.035N for the novice-intermediate 2.

As the mean force relies on the minimal force, it diminishes its discriminant power. We also calculate and compared the median force. By definition the median excludes the extreme values of the sample. However, in our study the extreme values are important because they help us differentiate between experience categories but also between individuals.

The time difference between the other categories is major, the greatest time is: 29.4 (novice 4) and the minimal time is: 2.03 (intermediate 3). We see in figure 9 the clear difference between categories despite expert-intermediate. We can conclude that time can be a discriminative measurement even though it has not been strictly protocoled. Moreover, the progression is very clear between categories (figure.8) showing its pertinence for future studies. Another advantage of time measurement is that it's already been validated in several former studies. We can then rely on it to validate other measurements.

The maximal force is, along with the time, the one discriminative measurement collected with our connected clamp (see figure 8 and 9). Analogously to the time, the maximal force varies greatly between the categories. Moreover, the maximal force evolution is similar to the time evolution as it can be seen in figure 8, which makes it even more interessant for further study as a clear evolution tendency seems to arise from our data.

Thanks to the data analysis, we can emphasis the importance of focusing on the maximal force and the time for further study as they are more discriminant.

4.2 STATISTICAL ANALYSIS

First of all, we have to emphasis that the Z-test rely on a normal distribution and therefore, require a minimal sample size of 30. As our sample size is only 4, this analysis is only an approximation. Moreover, most z calculated values were negative showing the lack of sample size. Therefore, we focused our statistical analysis of the z-test on the most relevant data found in figure 8 and 9: maximal force and time.

All the Z-test for the maximal force were significant despite the intermediate-novice/novice difference. We can see that this test can not be conclusive as the dispersion in the novice category is very high (variance = 19.92 N). The novice category was heterogenous by its experience in surgery but also by the spontaneous force they used on the clamp. A bigger sample will erase this heterogeneity by bringing more participants and more profiles.

	Expert/intermediate	Intermediate/ Intermediate-novice	Intermediate-novice/ novice
P value MF $\alpha = 0.05$	0.469402	0.126366	0.038066

Despite our expectation, all the time z-test weren't statistically significant as the intermediate/novice-intermediate wasn't significant. However, by looking a the data, we can see that there is a great variation in the intermediate-novice category (variance = 30.81) invalidating the test. As this category involve only two participants, we can not conclude that there is a pattern. We can also say that the intermediate-novice_1 had to restart the knot because it didn't hold, which can explain the great difference between the two participants. Once again, a greater number of participant would prevent such results.

4.3 STUDY LIMITS

While analysing the data and doing the experiments, four main limits emerge: the absence of strict time protocol, intermediate selection, novice heterogeneity and sample size.

First the time strict protocol should have been put in place at the start of the study. Indeed, we didn't used a new suture for every participant which can modify the time needed for a participant to tie the knot. The start and the end of the experiment was not clearly defined. The signal was given by the participant and the examiner will start the recording. For further study, we will need to give every participant a new suture and to protocol the beginning and the end of the experiment. By preparing the vessel and positioning the instruments at the start of the experiment and instructing the participant to place it back when they're finished, we will prevent from time difference from a participant to another. It will also be necessary to tell the participant not to put pressure on the clamp before actually beginning the knot tying to prevent from false data. However, we can still see in figure 9 that time is an important discriminant of surgical experience and, therefore, useful for further study.

The intermediate selection has becoming a problem quite early on the experience, that's why it had been separated in two categories: intermediate-novice and intermediate. In fact, our selection criterion weren't strict enough[3]. Even if the z-test proved that every category were statistically different, the results showed that the difference between intermediate and expert is less important than between the other categories. It can be explained by the fact that learning plateau is almost reach by participant with more than 6 months of microsurgical practice. Therefore we can ask the relevance of this category for a study aiming to discriminate surgical experience. Therefore, for a further study, we will have to concentrate on the intermediate-novice.

The novice were all medical students with no microsurgical experience. However, their surgical experience was really different. In one hand, Novice.1 didn't perform any knot tying before and didn't manage to complete the experience. There for a minimal surgical experience might be necessary to enrol further study. In the other hand, Novice.3 did had three months of surgical experience before and performed better in time and maximal pressure than the other novice. A better selection of medical student will be difficult dough because of the lack of official training and the absence of surgical logbook during the 6th year of medical study. It might then be pertinent to choose medical student from year below and give them a microsurgical training before the experience.

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[3] *See 3.2 subjects*

We can also say that the sample size wasn't sufficient to ensure statistical performance. As this study is only a pilot study, the sample size couldn't have been more important. For further study, a minimal of 30 participants per categories will be required

4.4 PERSPECTIVES

This pilot study has brought us different perspective for further studies.

First of all, we have proven that the maximal force and time are most discriminative measurements and proven that the connected clamp is a discriminative tool for hand dexterity. Hence, we will now be able to create different connected instruments to not only know the pressure put on the needle but also on the living tissue.

In further study we will be able to focus only on these measurements to create learning curve and pedagogical tools more efficiently. We will enrol a group of medical students in order to follow their improvement until they reach the expert level. With the measurements collected, which will help us understand the steps of microsurgical learning and create an educational tool. Moreover, the tendency of the intermediate data to approach expert data indicate us the existence of a learning plateau. We will found out how many knot tying a novice will have to perform to reach this plateau and the sufficient surgical expertise to perform on patients.

Our long-term goal is to create a learning program based on the connected clamp. We will not only create a learning tool but also validate what make a gesture effective. Indeed, so far the Haltedian model obligate the apprentice to lean its mentor gesture with no guarantee that this method is better. The software, completed by a direct audio signal to the participant, will allow him/her to ameliorate its technique to approach the validate gesture.

To complete the knowledge brought by the connected clamp, we will couple it with an optoelectronic system, EMG and EEG to link the pressure profile with the muscles and brain activities. This association could help us understand how exactly a senior surgeon moves his hand in comparison to doctors of a different level but also to understand the cerebral optimisation of energy acquired during the surgical residency. Further, we might be able to use such information to find new teaching methods for surgical residents. However, as the EMG and EEG have never been used to analyse microsurgical movements yet, it must be tested to collect data and to evaluate its capacity of discrimination between the dexterity of different surgical expertise. We will have an idea of the steps that makes a medical surgeon - from its brain activity to the pressure he/she applies on the instruments.

ANNEXES:

1.REFERENCES:

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2. INFORMATION SHEET

INFORMATIONS AUX PARTICIPANTS :

QU'EST-CE QUE LA MICROCHIRURGIE ?

La microchirurgie est une sous-spécialité de la chirurgie. L'œil du chirurgien y est assisté par microscope, les gestes de ce dernier sont alors guidés en permanence par un grossissement optique.
La microchirurgie permet à la fois une plus grande précision des gestes opératoires mais aussi de réparer des tissus visibles uniquement sous microscope.

QUELS SONT LES INSTRUMENTS UTILISES ?

1. JEWELER'S FORCEPS :

Pince de très haute précision qui permet d'utiliser un fil 10.0.
Elle doit être utilisée dans la **main non dominante** afin de maintenir **le tissu** pendant la suture.

2. PORTE-AIGUILLE

Pince fine courbée sans verrou (= on ne peut pas lâcher la tension sur la pince sans que l'aiguille ne tombe.) utilisée pour tenir l'aiguille lors de suture.

3. CISEAUX :

De dissection : Extrémités courbées et pointes arrondies. Utilisés pour disséquer autour du vaisseau.
Pour l'adventice : Extrémités droites et pointes fines. Utilisés pour couper les sutures et l'adventice des vaisseaux.

4. LE MICROSCOPE :

La netteté est ajustée en approchant/reculant le microscope à l'aide des poignées latérales. Il n'est pas nécessaire de changer le réglage des binoculaires. Si vous êtes porteur de lunettes de vue, il est nécessaire de les porter durant l'exercice.
Une fois la netteté obtenue, il n'est plus nécessaire de manipuler le microscope.

QUELQUES CONSEILS AVANT DE COMMENCER :

Pour éviter les trémors :

- Ne pas consommer plus de caféine que votre consommation habituelle avant de venir en séance de microchirurgie.
- Ne pas faire d'exercice physique intense impliquant les membres supérieurs moins de 24h avant les séances.
- Fumer votre dernière cigarette au moins 30min avant le début des exercices.
- Avoir une bonne nuit de sommeil.
- Garder son calme.
- Adopter une bonne position, la surface ulnaire des mains et les avants bras en supination sur une surface fixe.

Pour bien manipuler l'aiguille :

- L'aiguille doit toujours être à l'horizontale, elle ne doit ni pointer vers le haut ni pointer vers le bas. Pour ce faire, il est nécessaire de bien placer l'aiguille dans le porte-aiguille. Pour vous simplifier la tâche, prenez le fil à l'aide du Jeweler's forceps et déposer l'aiguille sur une surface fixe jusqu'à ce qu'elle soit stable, puis la fixer dans le porte-aiguille.

Les quatre règles d'or pour une bonne suture :

1. Toujours garder l'aiguille horizontalement parallèle au vaisseau.
2. Toujours voir où le bout de l'aiguille se déplace, ne jamais le deviner.
3. Soulever la berge que l'on veut suturer pour mieux la visualiser et la séparer de la berge que l'on veut éviter.
4. Toujours s'assurer que son nœud est plat tout en veillant à ne pas croiser les instruments.

QUELLE EST LA MARCHE À SUIVRE ?

Lors de cet exercice, le vaisseau aura été préalablement préparé (disséqué, adventice retirée et vaisseaux dilatés). Votre tâche constituera donc à poser un point simple de suture sur ce dernier.

1. LE POINT SIMPLE DE SUTURE

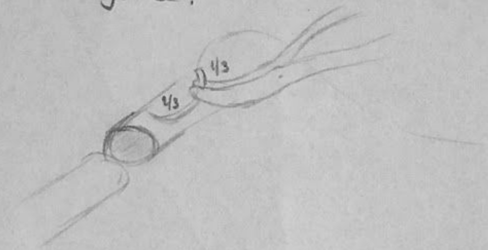
-Fixer l'aiguille dans le porte aiguille à l'aide du Jeweler's forceps.
- Soulever le vaisseau avec l'aiguille par l'adventice afin que la lumière de ce dernier soit bien visible.
- Passer dans la lumière les Jeweler's forceps.
- Diriger l'aiguille vers l'extrémité du forceps. L'aiguille doit être **parallèle au vaisseau et légèrement dirigée vers le bas**, mais en aucun cas perpendiculairement au vaisseau. Si l'aiguille est dirigée perpendiculairement au vaisseau, le risque d'imbriquer la paroi sous-jacente dans la suture est très important. En même temps, légèrement plier vers le haut la paroi du vaisseau grâce au Jeweler's forceps.
- Placer le point de sortie de l'aiguille à **équidistance** sur l'autre berge du vaisseau et y positionner la pointe du Jeweler's forceps. Plier la paroi du vaisseau vers le haut et faire ressortir totalement l'aiguille.
- Fermer la suture avec **trois demi nœuds**. (= faire une boucle autour du forceps puis grâce à ce dernier y faire passer l'autre extrémité du fil puis tendre dans l'axe de la suture)

SCHEMA ET VIDEO

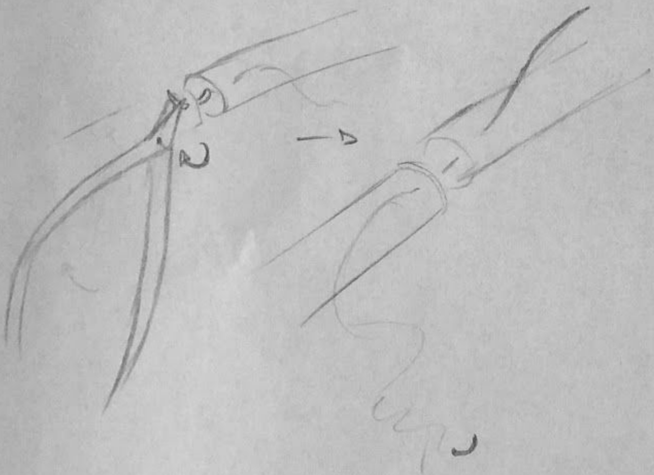
1. Vidéo :

https://m.youtube.com/watch?v=vDRkLJYLrvI&index=8&list=PLee7KYh_q9oJ2QutwRTDzbOWayHtI5KTp

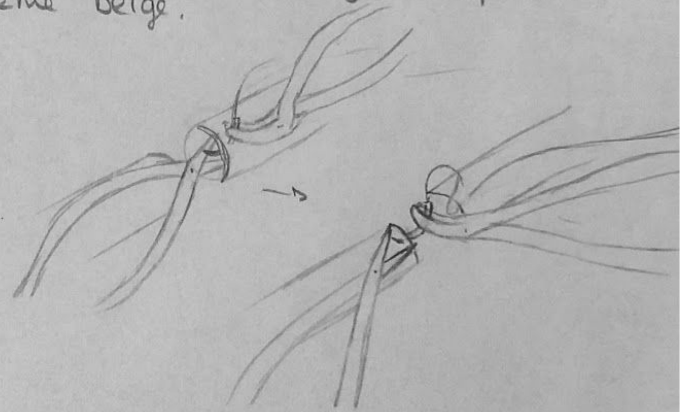
① - poser l'aiguille sur une surface plane à l'aide du forceps puis le prendre au 2/3 ⊥ au porte aiguille.



③ - retirer l'aiguille grâce au forceps via un mouvement rotatoir du poignet. Tirer le fil afin de laisser uniquement la portion nécessaire à la suture.

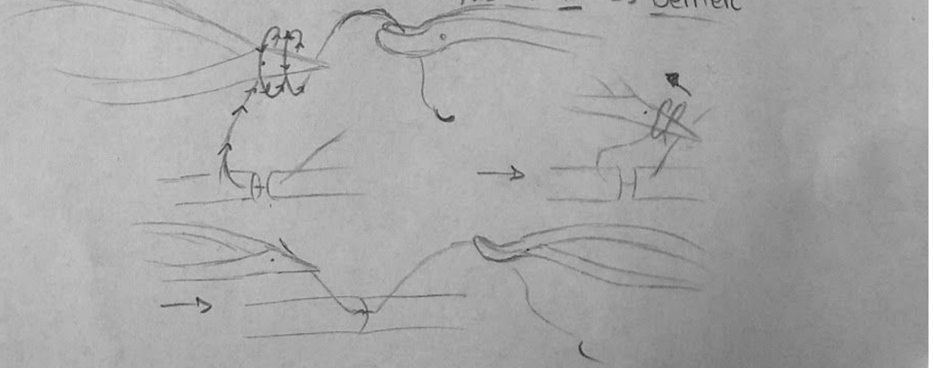


② - passer l'aiguille ⊥ à la 1ère berge du tissus, effechuer une pressiau à l'aide du forceps ouvert pour passer l'aiguille. Répéter sur la 2ème berge.



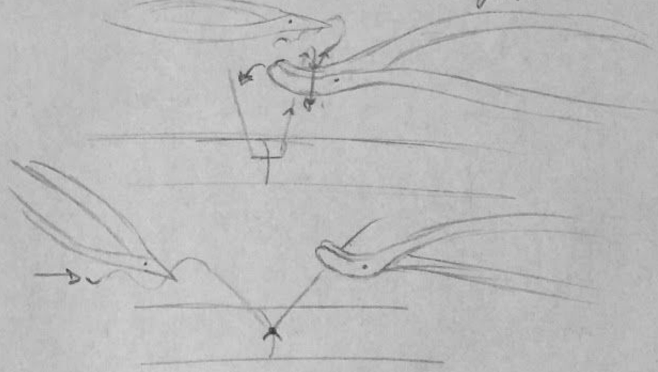
④ - effechuer un noed double en enroulant 2x le fil autour du forceps à l'aide du porte aiguille. Tirer sur l'extrémité du fil grace au forceps SANS croiser les instruments

extrémité du fil à D ⇒ Derrière

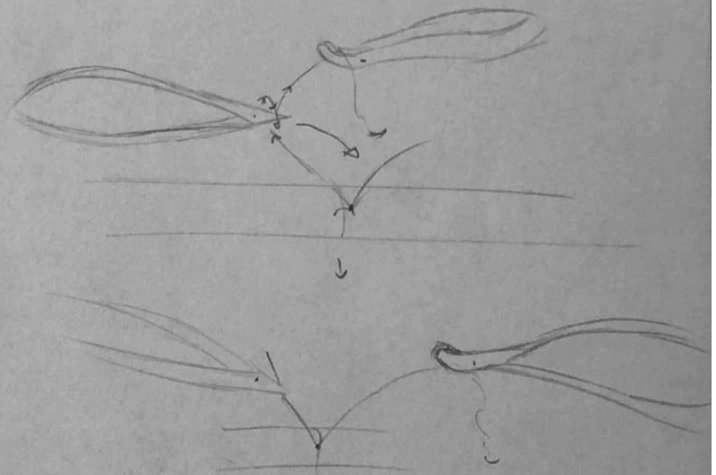


J. Lattion

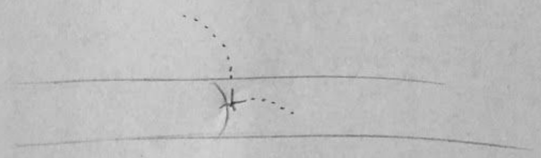
⑤ - Effectuer un noeud plat simple. Méthode similaire au noeud double. Pour ne pas croiser les instruments, enrouler le fil sur le porte-aiguille grâce au forceps puis tirer sur l'extrémité du fil.



⑥ - Dernier noeud plat simple. Enrouler le fil sur le forceps à l'aide du porte-aiguille puis tirer sur l'extrémité distale.



⑦ Couper les fils un à un.



J. Lattion

3. Z-TESTS RESULTS

Z-test force max	Test de la différence significative minimale (z-Test) EXPERT-INTER			Test de la différence significative minimale (z-Test) INTER-INTER.NOV			Test de la différence significative minimale (z-Test) I-N - NOVICE		
		2.072	3.049		3.049	7.672		7.672	10.19
	Moyenne	2.551	2.609	Moyenne	2.609	4.891	Moyenne	4.891	10.64
	Variances (connues)	0.91370533	0.22774933	Variances (connues)	0.22774933	3.8669805	Variances (connues)	3.8669805	19.9202577
	Observations	2	2	Observations	2	1	Observations	1	3
	Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0	
	z	-0.0767739		z	-1.1437404		z	-1.7735832	
	P(Z<=z) unilatéral	0.4694017		P(Z<=z) unilatéral	0.12636566		P(Z<=z) unilatéral	0.03806606	
	Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363	
	P(Z<=z) bilatéral	0.93880341		P(Z<=z) bilatéral	0.25273132		P(Z<=z) bilatéral	0.07613212	
	Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398	

z-test force moyenn	Test de la différence significative minimale (z-Test) EXPERT-INTER			Test de la différence significative minimale (z-Test) INTER-INTER.NOV			Test de la différence significative minimale (z-Test) I-N - NOVICE		
		0.6864297	1.209662		1.209662	1.6196774		1.6196774	1.8132666
	Moyenne	0.83132131	0.90755222	Moyenne	0.90755222	0.94114859	Moyenne	0.94114859	2.42609653
	Variances (connues)	0.01475653	0.04363153	Variances (connues)	0.04363153	0.23020067	Variances (connues)	0.23020067	1.02491821
	Observations	2	2	Observations	2	1	Observations	1	3
	Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0	
	z	-0.4461533		z	-0.0669234		z	-1.9636946	
	P(Z<=z) unilatéral	0.32774325		P(Z<=z) unilatéral	0.47332135		P(Z<=z) unilatéral	0.02478276	
	Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363	
	P(Z<=z) bilatéral	0.65548651		P(Z<=z) bilatéral	0.94664269		P(Z<=z) bilatéral	0.04956552	
	Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398	

Z-test force min	Test de la différence significative minimale (z-Test) EXPERT-INTER			Test de la différence significative minimale (z-Test) INTER-INTER.NOV			Test de la différence significative minimale (z-Test) I-N - NOVICE		
		0	0		0	0		0	0
	Moyenne	0.035	0.0095	Moyenne	0.0095	0.035	Moyenne	0.035	0
	Variances (connues)	0.0006125	0.00012033	Variances (connues)	0.00012033	0.006125	Variances (connues)	0.006125	1E-18
	Observations	1	2	Observations	2	1	Observations	1	3
	Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0	
	z	0.9831975		z	-0.3242385		z	0.4472136	
	P(Z<=z) unilatéral	0.16275512		P(Z<=z) unilatéral	0.37287875		P(Z<=z) unilatéral	0.32736042	
	Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363	
	P(Z<=z) bilatéral	0.32551025		P(Z<=z) bilatéral	0.7457575		P(Z<=z) bilatéral	0.65472085	
	Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398	

z-test med	Test de la différence significative minimale (z-Test) EXPERT-INTER			Test de la différence significative minimale (z-Test) INTER-INTER.NOV			Test de la différence significative minimale (z-Test) I-N - NOVICE		
		0.764	0.817		1.209662	0.762		0.762	0.708
	Moyenne	0.784	0.7905	Moyenne	0.90755222	0.812	Moyenne	0.812	0.848
	Variances (connues)	0.00032933	0.04363153	Variances (connues)	0.04363153	0.00125	Variances (connues)	0.00125	0.01697467
	Observations	2	2	Observations	2	1	Observations	1	3
	Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0	
	z	-0.0438425		z	0.62915384		z	-0.433131	
	P(Z<=z) unilatéral	0.48251498		P(Z<=z) unilatéral	0.26462417		P(Z<=z) unilatéral	0.33245978	
	Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363	
	P(Z<=z) bilatéral	0.96502995		P(Z<=z) bilatéral	0.52924835		P(Z<=z) bilatéral	0.66491957	
	Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398	

z-test temps	Test de la différence significative minimale (z-Test) EXPERT-INTER			Test de la différence significative minimale (z-Test) INTER-INTER.NOV			Test de la différence significative minimale (z-Test) I-N - NOVICE		
		2.4725	2.09		2.09	8.7192		8.7192	23.0425
	Moyenne	2.57465	3.205	Moyenne	3.205	16.57	Moyenne	16.57	26.55125
	Variances (connues)	0.08593333	1.79503333	Variances (connues)	1.79503333	30.8175303	Variances (connues)	30.8175303	12.4151762
	Observations	2	2	Observations	2	1	Observations	1	2
	Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0	
	z	-0.6499893		z	-2.3732106		z	-1.6403507	
	P(Z<=z) unilatéral	0.25784957		P(Z<=z) unilatéral	0.0088171		P(Z<=z) unilatéral	0.05046614	
	Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363	
	P(Z<=z) bilatéral	0.51569913		P(Z<=z) bilatéral	0.0176342		P(Z<=z) bilatéral	0.10093227	
	Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398	

z-test ecartype	Test de la différence significative minimale (z-Test) EXPERT-INTER			Test de la différence significative minimale (z-Test) INTER-INTER.NOV			Test de la différence significative minimale (z-Test) I-N - NOVICE		
		0.2239541	0.7509733		0.7509733	1.4983577		1.4983577	3.581111
	Moyenne	0.31848989	0.43024498	Moyenne	0.43024498	0.43311754	Moyenne	0.43311754	2.05377921
	Variances (connues)	0.02214443	0.05996108	Variances (connues)	0.05996108	0.56736827	Variances (connues)	0.56736827	1.4612349
	Observations	2	2	Observations	2	1	Observations	1	2
	Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0		Différence hypothétique des moyennes	0	
	z	-0.5515643		z	-0.0037167		z	-1.4225168	
	P(Z<=z) unilatéral	0.29062345		P(Z<=z) unilatéral	0.49851726		P(Z<=z) unilatéral	0.07743814	
	Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363		Valeur critique de z (unilatéral)	1.64485363	
	P(Z<=z) bilatéral	0.58124689		P(Z<=z) bilatéral	0.99703453		P(Z<=z) bilatéral	0.15487628	
	Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398		Valeur critique de z (bilatéral)	1.95996398	