“Each to their own”? An investigation into the spacing of laid-thread couching as used in textile conservation

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Introduction

Laid-thread couching is a common stitched technique within textile conservation. It is used to support damaged fabrics onto a stronger support material. This research project aimed to investigate the impact of varying the spacing of laid-thread couching in textile conservation treatments. This work is built upon that of Benson (2013), who investigated different stitching threads used for laid-thread couching. Benson stitched natural fiber samples with both natural and synthetic threads. These samples were subjected to a fixed-load experiment for a period of two weeks, after which they were examined using high-magnification images and scanning electron microscopy (SEM). Benson’s fixed-load experiments showed a different response to strain from staple and filament yarns. Many areas of further research were indicated, including stitching layouts and stitching technique.

The use of traditional hand sewing techniques, such as laid-thread couching, has been a core element of textile conservation. Despite long-standing use, little research has been undertaken to quantify some its “known” characteristics. This project was completed over 12-weeks as part of MPhil dissertation research at the Centre for Textile Conservation and Technical Art History, at the University of Glasgow. It was born out of an interest in the various ways in which decision making, specifically regarding laid-thread couching, can be taught. A literature review revealed limited quantitative analysis regarding laid-thread couching and only a few published case studies with reference to laid-thread couching variables. A detailed discussion of one particular treatment is given by Berkouwer (2014). The work of Ballard (1996), Ellis (1997) and Nilsson (2015) were also highlighted as pertinent to the research questions in hand.

Several different spacings of laid-thread couching were evaluated using fixed-load testing and digital image correlation (DIC).

These were subsequently examined using both quantitative and qualitative techniques. The wider project also recorded current approaches towards the spacing of laid-thread couching through a questionnaire sent out to practicing textile conservators. It is hoped that gathering this current collective knowledge will be of benefit to future conservators.

Research questions were formulated to allow the development of quantitative data, which could be used to understand the relationship between the spacing of lines of laid-thread couching and the effectiveness of a support treatment. These questions were:

- Does the spacing of laid-thread couching affect the strength of a treatment overall?
- Is there a "best practice" way of considering the spacing of laid-thread couching?
- Is it possible to use DIC to understand the strain in an area of laid-thread couching?
- How can conservators effectively communicate about laid-thread couching treatments?

Questionnaire

A questionnaire was sent out to practicing textile conservators to investigate current opinions on laid-thread couching. Participants were presented with a mock treatment situation, a cotton infant's gown (later used for actual testing), and asked to suggest what threads and spacing they might use in a similar situation. Responses were used to help decide on variables for the experimental phase of the research. The questionnaire also collected opinions on why laid-thread couching treatments were not often published and if participants felt they used a standard spacing when carrying out stitched treatments. In total 51 completed questionnaires were received, covering 12 different countries of work, and a mixture of both private and institution based practice. A total of 13 variables were recorded as impactful on the decision to use a particular spacing, including the size of loss, desired aesthetic and type of stitching thread. Most respondents agreed that these variables were often considered simultaneously based on previous experience – the gut feeling. All spacing measurements given in the questionnaire were between 2mm and 10mm, with 5mm being most popular. This tight range indicated that, to some degree, there is a standard range of spacing values. Lace-weight cotton thread was the most popular thread choice for this treatment, with fine polyester a close second.

Preliminary Testing

Following the results of the questionnaire, cotton thread was selected for the stitching of test samples. As a first step, the physical properties of cotton stitching threads were examined. Three different weights of “lace-weight” cotton were tested: Thread A - 120/2, Thread B - 160/2 and Thread C - 170/2, where the higher the first number the finer the thread. Warp yarns from the infant’s gown were also tested as they would be under the same stress as the stitching threads. Fifteen replicates of each stitching thread, and of the warps, were subjected to testing. This large group was chosen to allow for the assumed heterogeneous nature of the naturally aged cotton warps. Following British Standards (1996), a Constant-Rate-of-Extension (CRE) machine was used to conduct the tensile testing. The CRE machine was set to extend at 10mm per minute, using a static load cell of 100N. Individual threads and warps were adhered to paper frames to ensure each was positioned into the clamps under the same tension.

Several results were recorded and examined. Maximum load at break data was as predicted: the gown warps were the weakest, with the stitching threads gaining strength as they got thicker. Tenacity at maximum load was also as expected: the gown warps had low tenacity, while the stitching threads all had very similar, considerably higher, values. Both of these results for the stitching threads are due to their all being new and made from long-fibred Egyptian cotton. Importantly, the tensile testing phase highlighted the potential differences between different manufacturers’ threads for stitching.

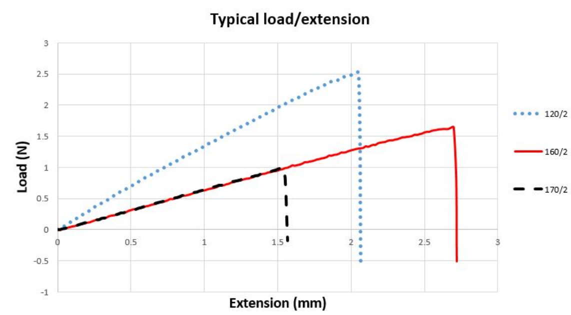
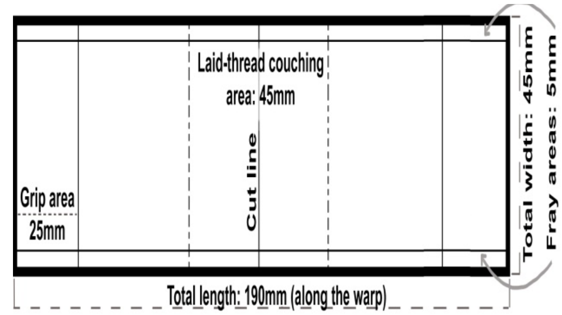


Figure 1

Figure 1 shows how Thread A (120/2) reveals a different pattern of extension from B (160/2) and C (170/2). Thread B and C are from the same manufacturer, whereas thread A is produced by a different company. This alone is a useful finding of the project. It suggests that a particular weight thread from one manufacturer may have different physical properties to the same weight thread from another manufacturer. Further research is required.

From this initial testing thread C was chosen to be the most appropriate for use in fixed-load testing. This is because it was suitably weak, whilst also demonstrating classic cotton tenacity. Due to its fineness, it would have also been the author's choice should tensile testing have been unavailable.

Figure 2



Fixed-load Testing

The second stage of tensile testing was to carry out fixed-load testing of several conserved samples. The cotton infant's gown, purchased for the testing, was chosen as it was known to have been worn, washed and handled regularly, whereas new fabric would have had different properties from a typical 'object'. Twenty conserved samples were prepared for the experiment: five replicates of each of four spacing variations. The chosen spacings were 3mm, 5mm, 7mm and 9mm - covering the range given by respondents to the questionnaire. All necessary fabrics and thread were left in the room where the experiments were conducted prior to hanging, to allow them to reach equilibrium with the room's ambient conditions. A pattern, based on that of Benson (2013) and British Standard (1996) guidelines, was drawn up to ensure that each sample set followed the same basic size and shape, see figure 2.

The 'damage' on each sample consisted of a single horizontal cut from one side of the sample to the other. Rectangles of a new, plain weave, cotton were cut and placed behind the damage. Lines of laid-thread couching were worked with a curved needle. Each stitched sample was hung in position with bar magnets from a magnetic notice board, see figure 3.

Figure 3

Several undamaged, unconserved strips of gown fabric were also hung as a control group. The samples were all weighted with 30g weights and left to hang for 21 days.

In order to use the data effectively, four stages of measurement were chosen during the experiment:

1. Initial extension: On the final day of hanging (day 21) the overall length of each sample was taken.
2. Initial recovery: Immediately after removal of the weight overall length was taken.
3. 48 hours unweighted: After the weights were removed, samples were left horizontal for 48 hours. Overall length was taken again.
4. One month unweighted: As above after one month.

All measurements were taken with a ruler to the nearest 0.5mm.

Quantitative Results

Prior to testing it was hypothesized that the wider the spacing (and therefore the fewer supporting lines) the greater the extension would be. General results matched this expectation.

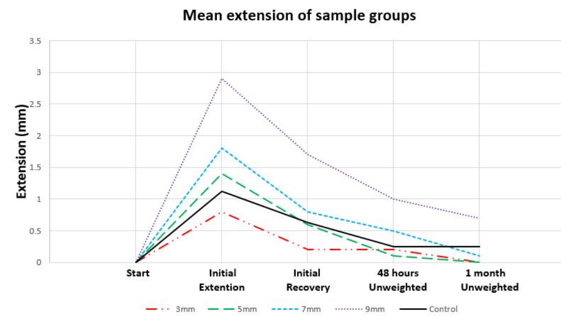


Figure 4

See figure 4, which plots the mean extension values for each set of data.

All samples were 140mm long at the beginning of testing. This was used as a baseline for calculating extension. The largest initial extension, 4mm, was found in the 9mm spacing group. The smallest initial extension was to be found in the 3mm spacing group, where one sample recorded no movement. All samples returned to within 1% of the original length (1.4mm) after 48 hours of being horizontal (unweighted). The four sets of conserved samples followed the predicted pattern, with a slight overlap between the 48-hour recovery of the 3mm and 5mm spacing groups. The data set which did not fit with the pattern is that of the control group. This group had greater extension than the 3mm spacing group, whereas a smaller extension would have been expected. This is likely due to the high density of laid-thread couching.

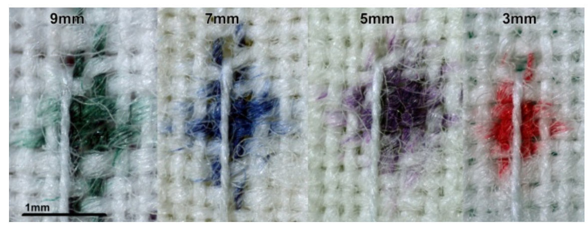
Figure 4 also shows that as the samples recovered they all moved back towards the same point regardless of initial extension: the groups which extended the most, also recovered the most. Standard deviation of all samples at each stage confirmed this: it was much lower, indicative of a tighter data-set, after one month of recovery, than after initial extension. This is a reflection of the nature of cotton fibers (in the stitching thread) to stretch slightly and recover (Cook, 1984).

Further statistical analysis, using *p-values,* was carried out to confirm that the wider the spacing, the greater the extension (the hypothesis), see table 1. A *p*-value equation measures the confidence in a value statistically. Working on a *p*-value of 0.01 = 99% confidence in the hypothesis, all results here can be concluded as agreeing with the hypothesis.

Qualitative Results

Slight deformation was noticeable along the upper end of each line of laid-thread couching. This was most apparent on the 9mm and 7mm group, where the wefts below the anchor weft were also slightly deformed. The 3mm group showed the least deformation. This indicates that where the load is spread over more lines of laid-thread couching, the impact of the load is less per line. Although all samples recovered overall, the deformation to individual wefts was not much improved through removal of the weight, as shown in figures 5 and 6.

Figure 5



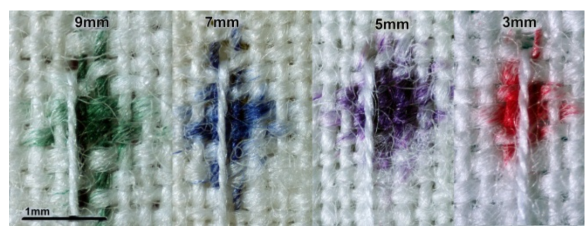


Figure 6

Deformation was also noticeable on the support fabric, particularly the 7mm and 9mm spacing groups, see figure 7.

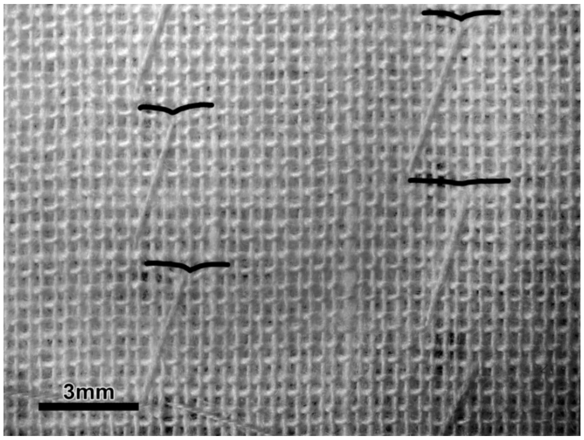


Figure 7

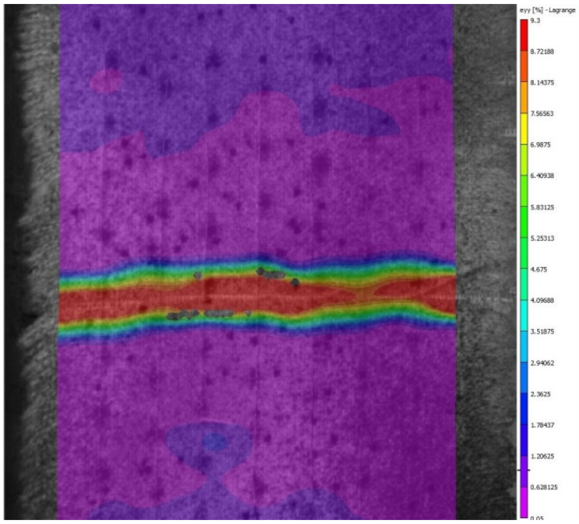
The support fabric was of a more open weave than the object: 26 wefts and 22 warps per 10mm, rather than 32 warps and wefts per 10mm. This difference is important to note as the loose or tight nature of a weave will impact how that fabric reacts to localized stress.

Digital Image Correlation

Digital image correlation (DIC) is an imaging technique which tracks the changes in surface geometry of an object through correlation of a deformed surface with its undeformed state (Dulieu-Barton et.al., 2005). It works by comparing digital images of a material at different stages of deformation. The movement required to superimpose the comparison image onto the starting image is what is measured as strain. The starting image and the comparison image are read by the correlation algorithm as a pattern of grey scale. To assist the computer software in identifying grey scale, a speckle pattern is applied to the surface of the material to be tested (Bossuyt, 2013). The measured deformation can be processed to give further information; the impact of a specific load on a material or the effect of environmental conditions such as temperature or humidity. DIC is, in principle, non-invasive and non-destructive which makes it particularly suitable for use with historic objects. Unfortunately, the need for a speckle pattern is a draw-back for some object observations, although success has been had observing strain in tapestries, where the texture of the weave can be used as a speckle substitute (Lennard et.al, 2011).

DIC analysis was carried out in partnership with the School of Engineering at the University of Glasgow. Various speckle patterns were attempted including the use of ink pens and matte spray paint. Due to time constraints only two spacings were tested, 5mm and 9mm. The small number of replicates tested meant that, although interesting observations were made, further research is required to produce conclusive results. Areas of high strain were noted particularly around the area of damage; see red-colored areas in figure 8.

Figure 8



This strain then quickly dispersed well before the ends of the lines of laid-thread couching, see purple areas in figure 8. It had been expected that some strain would have been noted around the tops of each laid-thread line, as these are the points carrying the weight of the treatment. No high strain was apparent there.

Discussion

The results of the practical experimentation back up information provided by practicing conservators in the questionnaire. Understanding how “strong” or “weak” an object, or a treatment is, is a skill built through experience and observation and is not necessarily something which can be taught quickly. The apparent lack of published information on the application of laid-thread couching is appropriate as conservators do not routinely look for these details in published sources, reflecting their reliance on their intuitive understanding of the technique rather than a learned approach to laid-thread couching.

It is valid to note that the most popular spacing measurement – 5mm – did very well in testing, being most similar to that of the control group. It also took less time to stitch, and inflicted fewer stitch holes, than the 3mm spacing group. The “ideal” treatment is very much a balancing act of multiple requirements. This experiment showed that an overly high density of stitching can make the supported area less elastic than the rest of the object. In this experiment, the conserved samples with the most stitching (3mm group) were less elastic than the samples which had no damage at all. This over-stitching restricted the movement of the conserved area. When a conserved area reacts very differently to an unconserved area, for example when under strain, this can cause tensions between areas, eventually leading to further damage. The suitability of a particular density of stitching has to be judged on a case-by-case basis.

This project trialed the use of DIC to investigate the conservation of a textile other than tapestry and it asked many more questions than it answered. The success of DIC, for textile conservation purposes, relies on the inclusion within the project team of an engineer who understands the results of the tests and can accurately interpret them. Taking images and processing them is simple, if time-consuming. Taking the resulting strain-maps and relating them back to the original sample is difficult without a good grasp of the technology and the algorithms upon which the technology is based.

Further Research

Several areas were highlighted for future research. This project indicates that the choice of thread has a considerable impact on the long-term success of a treatment. A wider study, covering a variety of stitching threads and spacings, is recommended. Further investigations on how DIC can be used to understand strain across stitched support treatments would also be beneficial. Research into the appropriate and accurate application of speckle patterns for DIC would also be of benefit.

Spacing	Mean extension at each measuring point			
	Initial extension	Initial recovery	48 hours unweighted	1 month unweighted
3mm	0.8mm	0.2mm	0.2mm	0mm
5mm	1.4mm	0.6mm	0.1mm	0mm
7mm	1.8mm	0.8mm	0.5mm	0.1mm
9mm	2.9mm	1.7mm	1mm	0.7mm
	p= 0.008	p= 0.007	p= 0.008	p=0.008

Table 1: Mean and *p*-values for each data set

Conclusions

This research project aimed to examine one variable in a treatment which has many. Overall, this project has provided some solid data to back up intuitive elements of textile conservation work:

- Over-stitching can restrict the natural movement of an object fabric, potentially causing further damage.
- Under-stitching can cause gaping and deformation around the treated area, potentially causing further damage.
- Thread-choice and spacing need to be considered and balanced in order to ensure a treatment is strong-enough, without being too strong.
- Different manufacturers' threads can have different mechanical properties, even if they are the same fibre and weight.

The novel use of DIC proved some success, but further research is needed to fully uncover all of the technology's potential within textile conservation. This project only investigated one parameter - hanging textiles with laid-thread couching.

The higher the density of laid-thread couching lines, the stronger the treatment. It is the role of the conservator to individually assess where on this scale of "weak to strong" is appropriate for the object in question. From the point of view of the emerging conservator, sharing reflections on successful and, perhaps more importantly, unsuccessful stitched treatments will help equip the next generation of textile conservators with greater knowledge at the start of their careers. It is hoped that this discussion will continue, to allow wide-reaching reflection on the impact of laid-thread couching treatments on the objects they support.

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Materials:

Cotton Threads:

Claire's Lace
85 North Poulner Road
Ringwood
BH24 3LA
England

Fil au Chinios Egyptian Cotton 120/2
http://www.claireslace.co.uk/shop/index.php?id_product=391&controller=product

Egyptian Cotton (Flemish) 160/2
http://www.claireslace.co.uk/shop/index.php?id_product=318&controller=product

Egyptian Cotton (Flemish) 170/2
http://www.claireslace.co.uk/shop/index.php?id_product=319&controller=product

Captions

Figure 1: Graph showing typical load/extension curves for three cotton stitching threads

Figure 2: Basic pattern used for each test sample

Figure 3: Samples hanging during experimental phase

Figure 4: Mean extension and recovery for each sample set

Figure 5: Micrographs taken immediately after weight removal

Figure 6: Micrographs taken after a 48 hours recovery period

Figure 7: Deformation of support fabric

Figure 8: DIC “strain map”. Red= higher strain (9.8% eyy), Light purple = lower strain (0.5% eyy)

Table 1: Mean and *p*-values for each data set