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The Use of Textured Japanese Paper as a Filler for Leather Conservation: Exploring an Alternative to BEVA® 371

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THE USE OF TEXTURED JAPANESE PAPER AS A FILLER FOR LEATHER CONSERVATION: EXPLORING AN ALTERNATIVE TO BEVA® 371

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The work presented here aims to expand the use of Japanese paper for loss compensation in leather objects as an alternative to the more common and less sustainable use of acrylic media. The research builds out of earlier work by Charlotte Ridley (2017) and Yue Li (2021) and is focused on texture-capture based on a minimal palette of materials. This article demonstrates the comprehensive testing of Japanese paper for casting fills for textured leather and compares the results with fills made from the more common medium, BEVA® 371. Several different weights of Japanese paper and concentrations of Klucel G in ethanol were press-moulded into silicone rubber casts taken from both coarse and fine-textured leather objects. The moulds were also used to make BEVA®371b fills for comparison. The two types of fill were applied to the same objects from which the moulds were taken and while the BEVA® 371b fills capture more of the two textures, the paper fills were found to be easier to integrate into the leather with the use of 4 gsm Japanese paper with 15% Klucel G producing the most defined texture comparable to the BEVA®371b.

KEYWORDS: *Leather conservation, textured fill, Japanese paper fill, BEVA® 371, Klucel G, loss compensation*

1. INTRODUCTION

Filling losses in leather objects requires that the fill material should be as physically and aesthetically compatible and chemically inert with the leather, remain stable over time, and be sufficiently durable and flexible to allow for movement. Fills should be easily removable, yet strong enough to hold the repair and to withstand any mechanical stress (Berger 1972; Kronthal et al. 2003). Since leather is a water- and heat-sensitive material, conservators have been exploring methods that are less invasive, easily reversible and do not introduce extensive moisture nor heat, which means protein-based glues are generally inappropriate 'because of their moisture content and because most are applied hot' (Rivers & Umney 2003, p. 734).

This article reports on work that develops a method begun by others including Charlotte Ridley (2017) and Yue Li (2021) to demonstrate that cast Japanese paper fills offer a relatively quick and easy way to make textured flexible fills which can be made sufficiently durable for repetitive use for non-rigid leather items.

The casting of fills in various media has long been executed in objects conservation as well as more recently in book conservation. For example, in the 'experimental conservation treatment system' developed at the New York Public Library materials widely used in book conservation are combined with a casting method where silicone moulds are used to replicate the texture of the original surface. A 'blend of acrylic gel, additives and paint media is specially formulated' and a pre-textured fill cast from the mould that can be attached directly or via supporting media like a textile (Owen & Reidell 2011, p. 250). The authors prefer acrylic-based fills as they are 'less invasive, thinner and visually more compatible than bound volume repairs with new leather or Japanese papers' (Owen & Reidell 2011, p. 250).

Where this might suggest comparison of acrylic-based fills with Japanese paper fills, this article offers the main author's observations on comparing the latter with fills made using ethylene vinyl acetate, BEVA® 371, commonly used by leather conservators.

BEVA® 371 was originally available in two forms, as a resin solution and a prepared film, both of which furniture conservators, for example, have found practical to use (Rivers & Umney 2003, p. 735). Christopher Calnan, working on leather upholstery in the early 1990s, also found both versions easy to use and noted there was no loss of bond strength nor flexibility (Calnan 1991).

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Similarly, the use of paper for cast fills is not new, with Ann Boulton in the mid-1980s using it to fill a pair of early 1840s sealskin boots (Boulton 1986). While the author filled some holes with goldbeater's skin adhered with BEVA®371, the author also used cast paper fills—made from macerated Japanese tissue, acrylic paint and wheat starch paste—to fill larger areas of loss, adhering them to more goldbeater's skin before fixing the cut-to-shape assemblage in place with BEVA®371.

2. Aims of the study

Recently, conservators Charlotte Ridley and Yue Li both used Japanese papers for the infilling of semi-rigid examples of imitation leather objects, an electric piano covered in 'Tolex, a leather-textured, vinyl-coated polyester textile' (Ridley 2017) and a mid-twentieth century photographic album covered in 'imitation leather' (Li 2021).

Ridley experimented with a layered Japanese paper technique to make a fill for a hole on the corner of the electric piano. Solubility tests had shown that the ketones and aromatic hydrocarbons in BEVA®371 would have damaged the object and Ridley also wanted a treatment option that is easy to remove. Ridley used five layers of Tosa Usushi 15gsm kozo paper laminated with 15% Klucel G in IMS (industrial methylated spirits) and tamped them with a stiff brush onto a silicone mould of the textured Tolex surface. Ridley reported that layering thin papers resulted in more defined texture than using a single layer of thick Japanese paper and concluded the blogpost by speculating that the technique could be successfully used for other types of leather objects especially if experimenting with different paper weights and adhesives to obtain the desired appearance (Ridley 2017).

Li similarly treated an imitation leather album where 'the losses in the covering material needed to be filled to give the album a better sense of aesthetic wholeness' (Li 2021). Li opted for 'two layers of 9-gsm Japanese spider tissue' casting the textured surface by applying the layers first in 5% Klucel G in ethanol followed by 15% Klucel G in ethanol into the silicone mould. Li then cut the patches and applied them to the album cover using a mixture of Japanese wheat starch paste and EVA (50:50), pressing the edges with fingers and a bone folder. Li concludes that the finished fill 'matched the original leather quite closely' (Li 2021).

Inspired by, but in contrast to these authors, this study continues the work of Ridley and Li and while it revisits a version of their texture-transfer technique on a semi-rigid fine-textured pigskin covered album it also expands their work to empirically compare Japanese paper fill composites on a coarser grained and, importantly, flexible leather bag against fills made using the more common BEVA® 371b. It should be noted here that as colour matching was not a focus of this work and all images here are in greyscale.

3. Treating losses to leather objects

New leather, animal and fish skin, textiles, Japanese tissue paper, cellulose and leather powders, along with acrylic or vinyl films and pastes have all been used to compensate for losses in leather objects, with many used in combination to obtain optimal results. This variety of materials also indicates the difficulty in establishing a single satisfactory solution for filling losses in leather.

Marion Kite and Roy Thomson suggest how using new leather can give a robust repair which will react to changing environmental conditions in sympathy with the original leather once a compatible leather is found (Kite & Thomson 2005, p. 126). Munn reports how using new leather can be particularly suitable for major losses (Munn 1989). Shayne Rivers and Nick Umney write in the context of leather on furniture how, if a suitable leather is found, it is preferable that it 'has been vegetable tanned and then retanned with aluminium salts' for chemical stability before use as a fill (Rivers & Umney 2003, p. 734). They also suggest the use of 'unfinished leather' can be useful as it can be more easily colour matched using azo metal complex dyes. However, all these authors note that it is often impossible to find a matching leather especially in terms of weight and grain as well as tanning method.

Other skins, such as fish skin and goldbeater's skin (cow intestine), have proven to be strong, resilient, transparent, deformable without breaking and present an even thickness (Munn 1989). These have been used to fill holes or to support mends (Jutrzenka-Supryn & Rosa 1995, p. 113), with Munn reporting how a slashed hole was filled with a thin parchment and the mend supported with an overlay of fish skin on both sides (Munn 1989).

Textiles, such as sailcloth or woven cloth, have also been used but with each limited by its particular qualities, including weight and texture or weave, which can become apparent over time (Kite & Thomson 2005, p. 126). Spun-bonded polyester fabrics, such as Reemay® and Vilene®, are much lighter without any discernible weave or nap and so can overcome these issues and move with the leather, rather than exerting any forces to it. However, their use is limited to small repairs or relining and backing (Kite & Thomson 2005, p. 126).

Kite and Thomson also found Japanese tissue paper to be ideal where a sacrificial repair is required as it is generally weaker than leather (Kite & Thomson 2005, p. 126). The advantages of Japanese paper include that it is easy to colour, it sticks with most adhesives and it is stable. Japanese paper is available in various thicknesses and colours and, as already mentioned, its pulp can be used to fill holes on leather objects (Boulton 1986). However, while the appearance of the paper fills can be made to resemble old, degraded leather it is often dismissed by leather conservators because its fibres can remain visible (Reidell 2019) and, importantly here, paper repairs are seen as being non-durable as they can be easily abraded and having issues in texture compatibility, especially in high relief patterns (Owen & Reidell 2011, p. 251; Reidell 2019). Furthermore, Japanese papers pasted together can create a hard composite which can be inflexible and with the pressure induced in opening something like a book it can cause a tear in the original leather (Girard 2018).

As such leather conservators have tended to rely on synthetic polymers for making cast fills. While proteinaceous-based fills have generally been avoided because of heat and moisture-related issues (Rivers & Umney 2003, p. 734), synthetic polymers such as Lascaux 360HV and 498HV (Owen & Reidell 2011), Paraloid F-10 (Bonnot-Diconne et al. 2001), Paraloid B72 (Chiotasso & Costantino 2007), polyvinyl acetate (PVAC) resins (grade AYAA and AYAC) (Kronthal et al. 2003), and blends of Golden Artists Colors GAC100 and GAC500 Acrylic Polymer media (Reidell 2019) and Golden Heavy Body Acrylic Colors, Heavy Gel Medium and GAC 200 (Owen & Reidell 2011) have all been variously used for a long time. Many of these mixes can be poured directly to a loss or crevice, or a film can be made and cut to the shape. Some of these materials have been used in putties and pastes with, for example, damage caused by insects was filled with putty made from leather powder and PVAC (Jutrzenka-Supryn & Rosa 1995, p. 113).

Some of the negatives in using of synthetic polymers include that they often need reworking to ensure a smooth surface and uniform adhesion, and when poured directly they can spill or seep into the immediately surrounding leather surface (Kronthal et al 2003). Other problems include remaining tacky on drying, having only partial reversibility and some presenting a lower pH over time where, especially with PVACs, acetic acid can be produced as a degradation product (Down et al. 1996). However, one of the great advantages of polymers is that they remain flexible once set. Furthermore, various lining materials can be paired with them to obtain suitable strengths, such as woven polyester, Japanese paper, and goldbeater's skin (Kronthal et al 2003).

One non-acrylic polymer that has shown consistently good results is BEVA®371. Originally used in painting conservation (Ploeger et al. 2015) it is a mouldable material that when compared to acrylics such as Lascaux 360HV or PVACs, BEVA®371 does not show any tackiness after drying (Owen & Reidell 2011). Different surface finishes can be achieved by adding other materials such as, for example, cellulose powder to produce a surface similar to deteriorated suede (Kronthal et al. 2003). Pigments and glass or ceramic microspheres can also be mixed to help achieve good colour and texture matching (Girard 2018). While, for various reasons many book conservators have found the use of BEVA®371 unsuitable (Owen & Reidell 2011, p. 251), on other leather objects it has become commonplace (Girard 2018; Kronthal et al. 2003; Rivers & Umney 2003) as it has good bond strength with leather and is both durable and reversible.

Some of BEVA®371's limitations include that it can alter the translucency of thin, vulnerable skin when heat-set (Fenn 1984) and while its melt point of around 65°C (Ploeger et al. 2015) is lower than the denaturing temperature of new leather of 80–90°C (Larsen 1996), it means that with aged leathers which can be more sensitive to temperature it should not be reactivated directly on them (Girard 2018). Furthermore, if the surface of the leather is painted with friable pigments any later attempt at reversing the fill with solvents could drive the adhesive into the pigment and alter the colour (Kronthal et al. 2003). Direct pours into cracks can also darken the original leather (Girard 2018). Solvent vapours can also be a concern especially where no fume extraction equipment is available (Girard 2018).

4. Experiments

4.1 preamble

Systematic experiments with synthetic fills and paper fills on the same leather object do not appear in the literature to compare the two methods side by side. Where this has been done is with leather book bindings, but although some requirements are common to other leather objects, such as chemical stability and reversibility, things like strength requirements are different as other objects may not require durability under repeated flexing that a book binding does. Therefore, in this work the experiments were primarily aimed at comparing the qualities of texture transfer offered by BEVA®371b fills and layered Japanese paper fills side by side on the same objects, with the assumption made that surface characteristic fidelity depends on the successful combination of different thicknesses of Japanese paper. Comparing different formulations of both Japanese paper and BEVA®371b in cast fills made with the same moulds and applied to the same leather objects would provide robust empirical insight on their texture matching abilities.

Furthermore, the experiments also aimed to explore a range of different adhesives to adhere the prepared fills to a leather object in terms of both their adhesion and flexural properties.

4.2 experimentation

Four main methods were trialled:

(a) making cast films of BEVA® 371b;
(b) making textured multilayered Japanese paper cast fills using different paper weights and concentrations of a standard adhesive;
(c) adhering both types of cast fill to a canvas lining to increase their flexibility and durability;
(d) adhering both types of cast fill into artificially made holes in two types of leather samples using common adhesives used in leather conservation.

4.2.1 Materials

(a) Leather samples

Two sample objects were used in the experiments: a flexible leather bag with a coarse texture and an old album with a fine-textured semi-rigid pigskin leather cover (Figure 1). The choice of samples with different textures was designed to reveal which material could better capture coarser or finer textures.

(b) Moulds

A fast set, two-component silicone rubber (Pinkysil) was used to take impressions of the leather samples as moulds. Pinkysil is suited to take intricate details and is able to be demoulded in about 30 minutes (Barnes n.d.).

(c) Fillers

(i) BEVA® 371b

BEVA® 371b is the 2010 reformulation of the original c.1976 BEVA® 371 developed by Gustav Berger. This original formulation, of two ethylene vinyl acetate copolymers, tackifiers made of an aldehyde ketone resin and a phthalate ester, paraffin wax and an organic solvent mix (Poulis et al. 2021), was made using Elvax 150, AC400, Cellolyn, wax and the now discontinued Laropal® K80 (formerly ketone N). BEVA® 371b was produced between 2010 and 2021 and replaced the Laropal® K80 with TegoVariplus. However, TegoVariplus was found to yellow and so in 2021 BEVA® 371a was released which uses Laropal A81 instead (TALAS1 n.d.). While the original BEVA® 371 film is still available (CPC n.d.) interestingly the current manufacturer indicates that Berger had anticipated alternatives for replacing the original components (CPC n.d.).

BEVA® 371b is only available as a dry resin mix and it was with this that the textured casts were made. As there was some premade BEVA® 371b solution in the lab where the work took place this was re-used by reheating it when required in a bain marie.

(ii) Japanese Paper

Three different Japanese papers were selected: 4 gsm Tengu paper extra light, 10.5 gsm Akaso kozo and 21.4 gsm Sekishu Mare (Anderson's Bindery 2021a, 2021b, 2021c). The three papers are made in Japan from the bast of mulberry trees. Ridley (2017) had successfully made the cast fills using 15 gsm kozo paper and as such the 10.5 gsm Akaso kozo was chosen as a standard—the 4 gsm Tengu paper extra light and 21.4 gsm Sekishu Mare were then selected to examine whether a thicker or thinner paper is capable of capturing the textures of the sample objects in detail.

(d) Filler Adhesives

Klucel G is a non-ionic adhesive that dries clear and flexible and is often used for leather consolidation (TALAS2 n.d.). It was used in a 15% concentration by Ridley (2017) and in 5% and 15% by Li (2012) for their Japanese paper fills. Where Ridley used industrial methylated spirits (IMS) Li found this distorted the initial paper fills and substituted IMS with ethanol to achieve much better results for the album. Ethanol was therefore chosen as the solvent for these experiments especially Klucel G in ethanol has the required flexibility when dried.

Klucel G was used not only to adhere layers of Japanese paper, but to modify the visual differences of Japanese paper to leather, including its matte, fibrous surface and opacity (Wikarski et al. 2015). It was also used initially to apply the infills to holes on the sample objects and to adhere the paper fills to the canvas lining.

Lascaux 498HV and Lascaux 303HV were also used as the experiments progressed, given the need for greater adhesive strength.

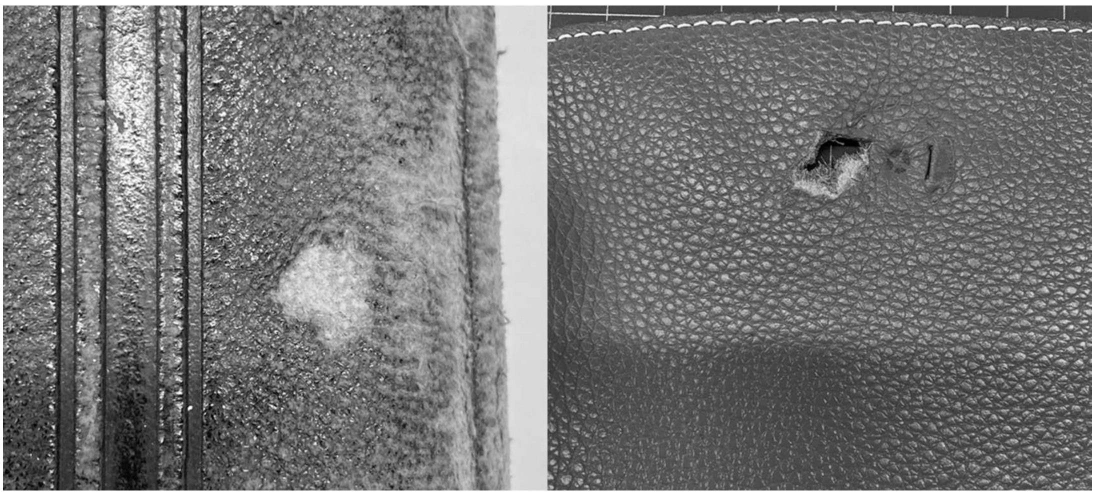

Figure 1. Composite image of the two leather objects: (left) early twentieth-century pigskin album; (right) contemporary leather shoulder bag.

Lascaux 498HV is a thermoplastic dispersion that dries hard and is composed of a water-based emulsion consisting of 56% butylacrylate–methylmethacrylate copolymer. Lascaux 303HV is an elastic thermoplastic copolymer butyl-methacrylate dispersion thickened with acrylic butyl-ester with pH 8–9. It is the replacement for Lascaux 360HV which is cited in most of the extant literature (Kelly et al. 2020).

Both 498HV and 360HV (303HV) are used in leather conservation as adhesives (Down et al. 1996) as they do not penetrate the leather readily and are easy to remove either with a solvent or by peeling (Kite & Thomson 2005). They can also be solvent-reactivated, which is useful to form a fast track without introducing moisture (Kite & Thomson 2005).

Lascaux 498 HV dries hard and has strength, while Lascaux 360 HV is reported as being softer and slightly tacky when dry (Kite & Thomson 2005). Best results are obtained when the two grades are mixed to get the flexibility of the 360/303 and the strength of the 498—if only 498 was used then the resultant harder adhesive poses the risk of a fill to pull away whereas the 360/303's tackiness provokes shifting mends and adhesive flow (Owen & Reidell 2011).

(e) Additional Materials

Cellulose powder was required as the experiments proceeded for the deeper holes. It was mixed with 5% Klucel G in ethanol, and microballoons were added to fill one gap (Fulcher 2017). Pre-stretched cotton canvas was used as a backing material.

4.2.2 Sample preparation

(a) Moulds

The sample objects, a red leather bag with coarse texture and an album with fine-textured pigskin cover, were cut with a cutter to mimic holes in leather objects.

For the leather bag, several small holes around 1–2 cm in diameter and some larger holes of around 3 × 5 cm were cut out. The album originally had scratch holes and some small holes which were considered to be insect damage. Some surface damage to the album were also used as they required thinner infills. This damage and a deeper and larger hole on the back of the album were all treated in the experiments.

Moulds of each textured surface were made by mixing the same amount of the two-part Pinkysil silicone rubber in a plastic cup with a glass stick, then being poured onto the leather samples to take impressions. The moulds were removed from the sample objects after about 20 minutes. The moulds were used throughout both sample making processes.

(b) BEVA® 371b Fills

Pre-made BEVA® 371b solution was added to a beaker and heated in a bain-marie continually stirred until no clumps were present. Some of the hot solution was then brushed onto a piece of canvas and left to dry. Metal and earth pigments (cadmium red and raw umber) were added to the rest of the solution and mixed with a glass stirrer and then the solution was left in the bain-marie to help reduce air bubbles. The coloured solution was then poured onto the canvas where the now dried BEVA® 371b had been applied and spread using a palette knife before it set. This had to be done quickly as the hot solution reactivates the base layer on the canvas making the layers stick together. While the layers remained tacky the mould was placed on top and left until the solution had set. Once set the mould was carefully removed.

Thirteen fills were made following this procedure and two fills made with the coarse texture and one fill with the fine texture were selected since they were most successful in achieving even thicknesses without detaching from the canvas lining.

The hole shapes in each object were traced using Mylar® and the fills were cut with scissors following the traced shape of the holes. The edges were pared with a cutter and a scalpel. The fills were adhered to the losses in the objects with 10% Klucel G in ethanol.

(c) Textured Japanese Paper Fills

Pieces of 4 gsm Tengu extra light (kozo), 10.5 gsm Akaso (kozo) and 21.4 gsm Sekishu Mare (kozo) Japanese paper were cut into approximately 7 × 10 cm rectangles using a cutter.

Solution of 5%, 10% and 15% of Klucel G in ethanol were each applied to one sheet of each paper which were then individually pressed into the silicone moulds. The papers were then tamped onto the mould with a stencil brush to ensure there were no air bubbles trapped between the mould and the paper. Successive layers of adhesive-coated papers were added and tamped until the desired thickness was achieved and the paper composite was then left to dry. After drying the textured paper fill was demoulded and was coloured using acrylic paints. The fill was then cut to fit the hole in the same way above using Mylar® templates and then adhered in place using 5%, 10% and 15% Klucel G in ethanol depending on how fine the textured sample was.

31 paper fills were made following this procedure using different thicknesses of paper, different concentrations of adhesive and different methods of colouring. Some of the fills required additional steps with, for example, two fills were first dampened with lower concentrations of Klucel G, tamped down on the mould, and then higher concentrations of Klucel G were applied to adhere the next layer of paper. This additional step allows the paper to soften and makes tamping easy as the paper was less likely to tear, and soft wet paper creates a more defined texture (see also Li 2021). Additional layers of the thicker paper were also added to six samples with Klucel G after the first layer had dried. 5% Klucel G was used to adhere the additional layers on one of the six samples

as 5% Klucel G had been used to tamp the initial paper layers. 15% Klucel G was used for the additional layers on the other five samples accordingly. These layers were added due to insufficient thickness, since most of the samples had the first layers made with the very thin 4 gsm Tengu extra light paper. Layers of thicker paper were added on two different samples, while their initial 10 layers of Tengu paper were still wet on the mould. These two methods of adding backing paper, one when dry the other while still wet, did not affect the visual quality of the fills. When dried, six sample fills were adhered to a canvas lining with 10% Klucel G. The aim of this step is to give some flexibility and thickness to the paper infills and the canvas lining was also pared before adhering the whole assemblage to the sample objects.

Although not the focus of this work the Tengu extra light paper was also pre-tinted with Golden Artist Colors acrylic paints before being tamped on the mould. Since the paper is very thin, it tends to tear when the paints were applied with a brush so as an alternative, the paints were mixed on a tile with plenty of water and the paper was dipped into the coloured water. The paper was dried on a tray before continuing to be tamped on the moulds.

Two fills used on the coarse texture object (the bag) and two fills made with the fine texture (the album) were chosen for the treatment experiments. All the selected fills were made of the 4 gsm Tengu extra light paper and the two fine-textured fills were backed with thicker paper layers to add thickness to the textured surface, and one of the two fills were pre-tinted. The two fills with the coarse texture were adhered to a canvas lining after the adhesive-coated paper layers had completely dried.

The fills were then cut and applied to the losses on the sample objects using Mylar® to trace the shape of the losses. The fills were then cut to the shape with scissors and inserted and adhered using 10% Klucel G in ethanol.

For the small holes and scratches in the fine textured sample, the paper composites needed to be finely pared and then adhered using a 5% Klucel G in ethanol. However, for the deep hole on the album the prepared composite of 10 layers of the 4 gsm Tengu paper was not thick enough for the loss and there was a dent visible after adhering. The fill was subsequently removed with water and a scalpel and a mixture of 5% Klucel G in ethanol and cellulose powder was applied to a deeper area of loss before a new piece cut from the same paper fill was adhered using the same percentage of Klucel G in ethanol.

For the coarse-textured leather bag, five small holes had been prepared and two composite fills were adhered using 10% Klucel G in ethanol, one with Lascaux 498 HV, one with 2:1 Lascaux 498 HV and Lascaux 303 HV, and one with 2:1:2 Lascaux 498, 303 HV, and deionised water (for the use of the last ratio, see Owen & Reidell 2011). Experimenting with different adhesives was aimed to discover which had the most suitable flexibility. For the two larger holes in the bag, the edges of the composite fills were pared with a scalpel, and one fill was adhered with 10% Klucel G in ethanol while the other was adhered with 2:1 Lascaux 498 HV and 303 HV.

One more hole was made to the corner of a pocket in the bag with the intention to experiment on the suitability of using the Japanese paper fills on a curved surface. The canvas lining on the back of the fill was removed for this infill because the corner required the reshaping of the paper fill which the canvas inhibited. The canvas was easily removed using water from the paper fill and the fill was then reshaped to match the corner and then adhered with 5% Klucel G in ethanol.

5. Results

The results from the use of the two types of textured fills will be evaluated here using three criteria: visual examination in terms of textural integration, the ease and replicability of the manufacturing process, and the success of their application to the sample objects.

5.1 BEVA® 371b fills

Overall, the BEVA® 371b-based fills captured the textures of both coarse and fine samples of leather. However, they presented issues in the manufacturing process and the success of their application.

5.1.1 Visual examination

BEVA® 371b captured the textures of the leather in detail, from both the coarse and fine samples (see Figure 2). Best results were obtained when the solution was spread evenly with a palette knife (in two samples) or poured directly (in one sample) and the moulds were applied before it had begun to set. 10 of the fills failed in terms of their texturing.

Some of the BEVA® 371b fills failed to capture the texture because of the entrainment of air bubbles when mixing. Mixing enhanced the evaporation of solvents, which thickened the solution making it easier for bubbles to be trapped.

5.1.2 Manufacturing process

Making evenly textured fills required some practice as the BEVA® 371b solution needs to be evenly but quickly applied to the canvas lining and the mould put in place before it starts its rapid set. If it took more than 15 seconds to spread the solution, large gaps and bubbles could appear between the two layers, although this can be mitigated by activating the bottom layer with a hot spatula through the canvas using a Mylar® sheet (Girard 2018). Another issue was that although glass tools could be cleaned with a relatively large amount of acetone, brushes had to be discarded.

5.1.3 Application

Because BEVA® 371b did not adhere well with Klucel G, it was necessary to adhere the fill by applying

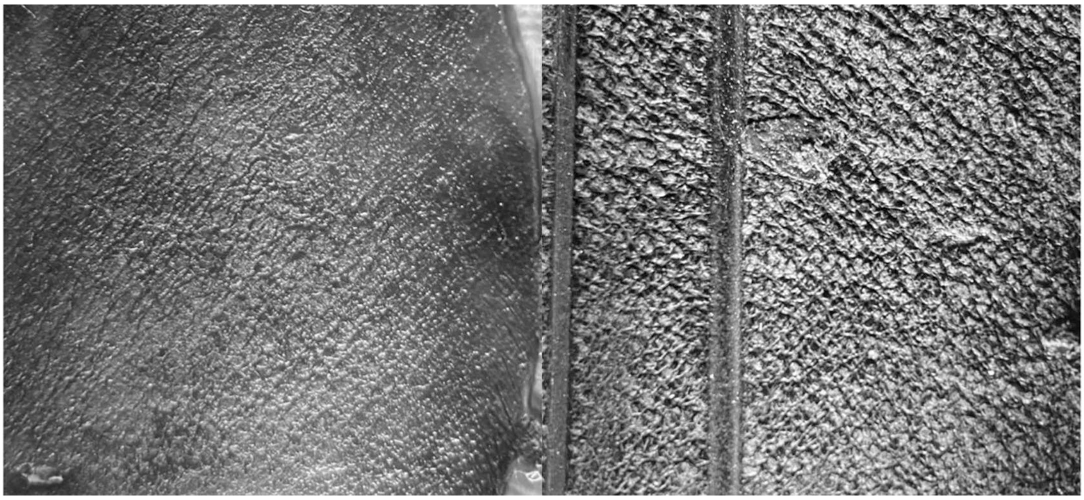

FIGURE 2. Left: BEVA® 371b cast of fine textured pigskin leather viewed under raking light; right: the original pigskin sample.

adhesive to the canvas liner. As the BEVA® 371b layer was thicker than the canvas, the fill proved unstable when the bag was folded only once, with one smaller repair separating at its edges from the host object. While the application of a small fill to a flexible area will most likely result in its eventual separation no matter how much flexibility or tack the adhesive may have, separation after only a single fold is obviously a failure (Figure 3). It should also be noted that in attempting to re-adhere the fill heat was applied using a heated spatula but this in effect only sealed the surface and, more importantly, it compromised the texture and made it shiny.

5.2 TEXTURED JAPANESE PAPER FILLS

Overall, the best capture of the two textures was captured when the finest Japanese paper was used with the highest concentration of adhesive. Pre-tinting the paper prior to coating with the adhesive was ideal since any subsequent painting introduced moisture to the paper and would disrupt the transferred texture.

5.2.1 VISUAL EXAMINATION

The best results were obtained when the finest (4 gsm) paper and the highest concentration (15%) of Klucel G in ethanol was used (Figure 4). While the 10.5 gsm paper could capture a less refined version of the coarser texture, for the finer texture only the finest paper was successful.

5.2.2 MANUFACTURING PROCESS

Although the 4 gsm Tengu paper produced the most detailed texture, it required some practice in handling as it teared easily which could then overlap to produce a disturbing line. This problem can be overcome by damping it in lower concentrations of the Klucel G. When using the thicker papers, especially 21.4 gsm Sekishu Mare, the layered fills became hard and less flexible when using the 15% Klucel G in ethanol.

Tamping down the paper into the mould was important not only to transfer the texture but to reduce any air bubbles trapped between the layers. Bubbles were more visible in the finer paper, therefore the tamping

FIGURE 3. Flexibility testing on a large BEVA® 371b fill and a small BEVA® 371b fill. The small fill detached after one fold.

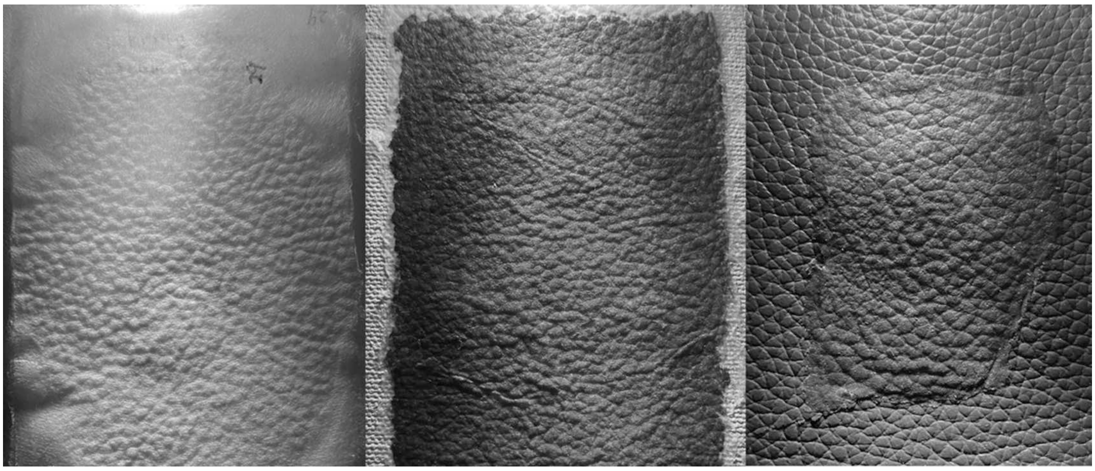

FIGURE 4. Left: 4 gsm Tengu extra light (5% Klucel G), middle: 4 gsm Tengu extra light (10% Klucel G), right: 4 gsm Tengu extra light (15% Klucel G) as applied to the leather sample. All under raking light. The higher the concentration of Klucel G, the more defined the texture.

process should be both extensively and carefully executed. It should also be noted that when painting the fills with acrylic paints after application, the texture can disappear as the moisture of the paints softens and disrupts the cast texture.

The transferred texture is also pressure sensitive, which means when the fill was applied to the canvas care was needed in not placing too much pressure, but enough for it to adhere. Sensitivity to pressure was the main issue when paring the edges of the fills, since the textured surface needed to be faced down on a cutting mat, and a certain pressure was unavoidable when paring the edges with a scalpel. Using the scalpel while the paper was still on the mould helps reduce the pressure, yet it could potentially damage the mould over time. Paring on a thin cushion also dispersed the pressure but this was not an ideal solution as it was unstable when using the scalpel.

5.2.3 Application

Textured paper fills adhered well with all the adhesives tested: Klucel G in ethanol, Lascaux 498 HV, Lascaux 303 HV and a blend of the Lascauxs. It should be noted that to remove fills adhered with Klucel G requires introducing water to the leather surface, which should be avoided as much as possible. From the perspective of flexibility, the Lascaux mix (2:1 Lascaux 498 HV and 303 HV) produced a more flexible and stronger bond.

Since the 4 gsm Tengu extra light paper would otherwise be needed to be layered many times to reach the desired thickness for the coarse texture sample, the paper fill was adhered to the canvas with 10% Klucel G in ethanol using a brush before adhering to the hole in the bag sample. This also provided greater flexibility to the paper fill as it was able to bend and fold multiple times without separating from both the object and the canvas lining (Figure 5).

Finally, in terms of application, when the deep area of loss on the album was prefilled with a blend of Klucel G and cellulose powder this then allowed for the application of the textured paper fill obtain a smooth surface.

6. Analysis

In this section, the comparison of both types of fills in terms of texturing, manufacture and flexibility will be discussed.

6.1 Visual examination

When comparing the contrast of the deep grains and flat surface of the original coarse leather, the texture of the paper fills is much less detailed than that of the BEVA® 371b fills (Figure 6). While the BEVA® 371b fills sometimes present air bubbles on the surface these can be reduced with practice and by slightly thinning the solution with solvents. By focusing on the results of transferred textures of the coarse sample only, it might be possible to dismiss textured paper as an alternative to BEVA® 371b fills in some cases.

For the fine-textured fills, the Japanese paper fills are almost as closely textured to the original leather as are the BEVA® 371b fills (Figure 7). The slight difference between the two cast textures could occur because

FIGURE 5. 4 gsm Tengu extra light paper fill in 15% Klucel G on a canvas lining during flexibility testing. The fill was able to withstand numerous folding actions without separating.

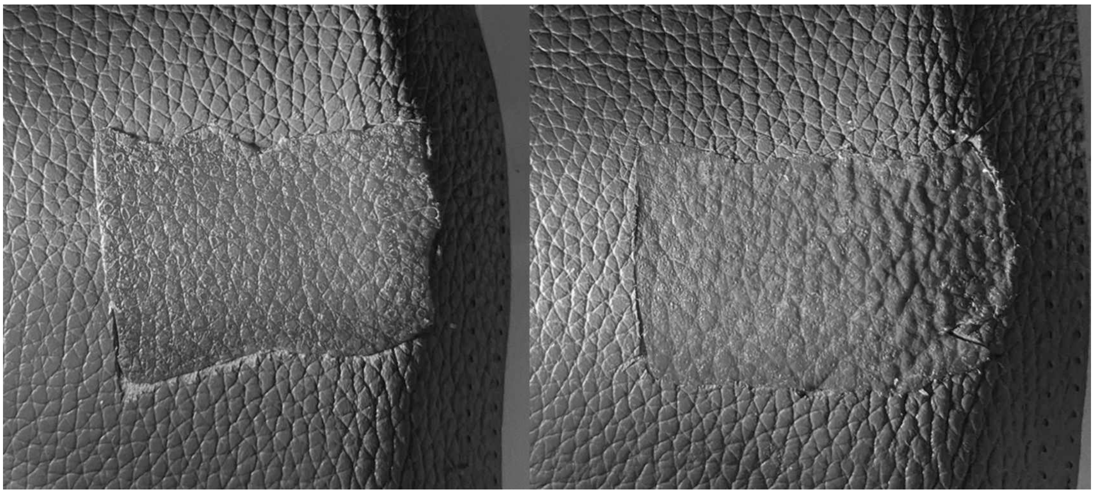

FIGURE 6. Left: BEVA® 371b fill to coarser leather sample, right: 4 gsm Tengu extra light (15% Klucel G), both under raking light. The BEVA® 371b fill has a more defined texture, however, its surface exhibits some unwanted bubbles.

the paper fills needed to be pared and the pressure caused by the procedure slightly altered surface definition. Arguably these can still be used successfully in any treatment of leather and Ridley (2017) and Li (2021) have also shown in their studies that paper fills can also replicate coarser textures that appear very similar to the original leather surface texture. In contrast, while the BEVA® 371b fills can be pared and can create less obvious repairs when the support is removed along the edges of the patch (Girard 2018; Owen & Reidell 2011), they are also elastic and difficult to make feathered edges for thicker fills. As such it is suggested that the thicker the fill required, the more suitable paper fills can be, due to the difficulty in paring thick BEVA-based fills, as the experiments revealed that textured paper fills produce less obvious fills because of their easier workability with a scalpel.

Finally, if the BEVA® 371b solution is not mixed with filler materials such as cellulose powder for matting, it remains semi-transparent and any lining material such as canvas will remain noticeable on the edges (cf. Girard 2018). While the Japanese paper fills can exhibit the same tendency, it is much less obvious.

Overall, textured paper fills are less likely to capture the texture at the same level of detail as BEVA® 371b fills, but their texturing is arguably defined enough to make a textured fill. They can even be less obvious repair if an area of loss requires a thick infill.

6.2 MANUFACTURING PROCESS

An even thickness of a fill is more achievable using paper fills as the rapid setting of BEVA® 371b mean the pouring and spreading of the solution and then applying the mould must be completed within about 15 seconds, making it more difficult to obtain the desired thickness. This can be improved by reactivating

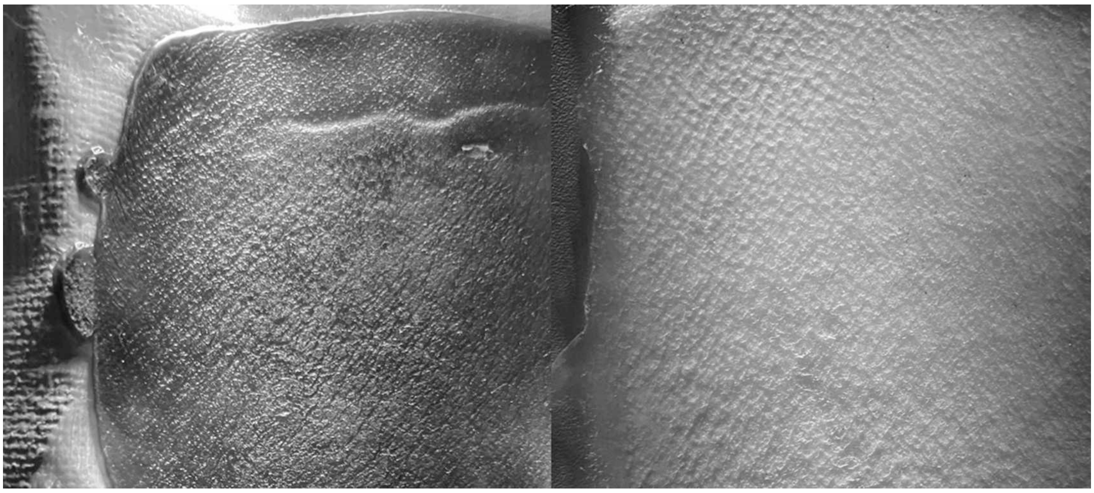

FIGURE 7. Left: BEVA® 371b cast of fine textured pigskin leather, right: the same leather cast using 4 gsm Tengu extra light paper and 10% Klucel G; both images taken under raking light. The paper fill is almost as textured as the BEVA fill.

the solution from the back of the canvas with a heated spatula but there is always the danger that step can make the desired thickness less achievable.

In contrast, a layer of Japanese paper can be added until the fill reaches a desired thickness, and the fill can easily be pared down if it is too thick. Although adding layers after a fill is removed from a mould should be avoided to protect the transferred texture, delicate adjustments in thickness is achievable. If a very thick fill is required, prefilling with a cellulose-based mixture before applying the paper fill is a practical solution.

6.3 FLEXIBILITY

Flexibility of the fills was tested by folding the fills manually, and as far as the experiments conducted for this study demonstrated, the BEVA® 371b fills are flexible and resilient, with the larger fills proving more durable than smaller ones, with one easily separating—the use of Klucel G to adhere both types of materials might be a factor here. Furthermore, the larger fills, though resilient, might damage the original leather if it is fragile.

Layered Japanese paper fills with a canvas lining showed less resilience but all were flexible enough to be folded without separating. As any intensive layering of adhesive-coated Japanese paper creates a hard composite, it is recommended that an appropriate lining material is selected first and then layered up according to the preferred strength, thickness and flexibility. This suggests paper fills can be versatile not just for visual compensation but in treatments that requires durability so, for example, if a fill needs to endure vigorous movement, a stronger adhesive can be used between the fill and a lining to avoid separation.

When paper fills are used without a lining, experiments found they can easily be bent to fit a loss on the corner or the edge. This kind of adjustment cannot be obtained in BEVA fills as they are so elastic and resilient that they return to the original flatness. If an area of loss is located on the corner of an object, or it is curved, paper fills are a superior option to consider as they can be fitted to the shape by bending with fingers (Figure 8).

7. Further recommendations

Since the study presented here formed a set of preliminary experiments, there are many aspects that could be developed for a more comprehensive survey and analysis.

7.1 MATERIALS

Suggestions for alternative materials for the future research are discussed in this section.

7.1.1 BEVA® 371 INFILLS

One of the problems of BEVA® 371b infills was that they did not adhere well to the sample object when using Klucel G. Adhesives other than Klucel G, such as Lascaux 498HV, Lascaux 303HV or mix of both, may be tested with BEVA® 371b fills. Mixing glass microspheres into the solution can help with adhesion as the inert filler provides some porosity for adhesion to take place. Girard (2018) recommends 1:2 (v/v) microspheres/BEVA® 371 solution, as a larger proportion of microspheres compromises the precision of the desired texture, and a lower quantity of microspheres makes the BEVA® 371-based leather distorted with the starch paste Girard used.

Making the desired thickness of BEVA® 371 infills can be made easier by diluting the solution with white spirit to extend its working time. This enables levelling of the solution more evenly with a palette knife or brush. Girard (2018) suggests a 1:1 (v/v) dilution in white spirit and Kronthal et al. (2003) state diluting it with xylene can also strengthen the adhesive bond. Boulton (1986) slightly diluted BEVA® 371 with toluene to achieve a brushable consistency for applying goldbeater's skin during treatment of a pair of boots from the Aleutian Islands.

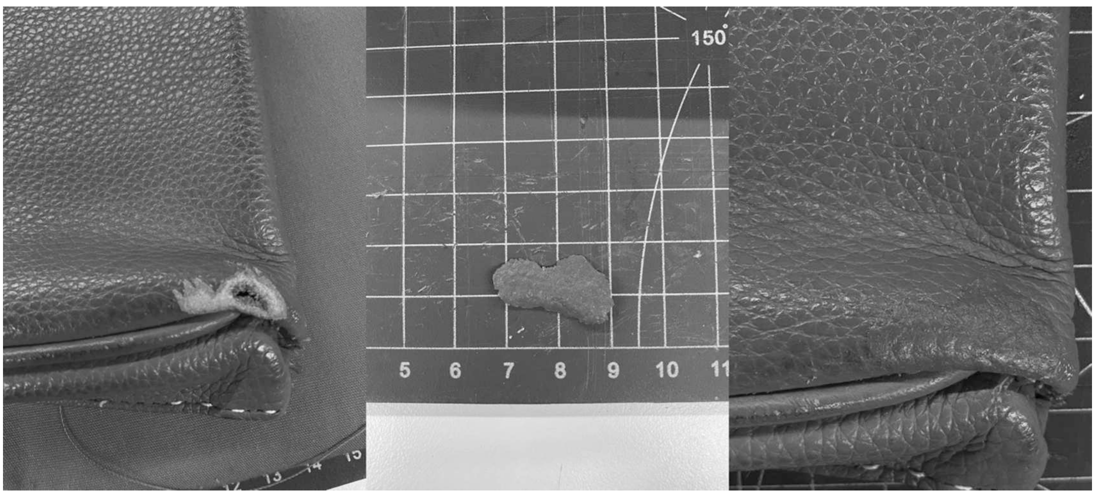

Figure 8. 4 gsm Tengu extra light paper in 15% Klucel G used as a corner fill.

Diluting agents and ratios should be further examined where BEVA® 371-based infills are considered to provide optimum results.

7.1.2 Japanese paper

Further research into using different weights of Japanese paper is needed. Although deciding on a suitable paper depends on the kind of object being treated, this study revealed paper with a lower weight (gsm) are best able to transfer a texture in detail. As described the 4 gsm paper is so thin that there can be issues with tearing and air bubbles during tamping according to the concentration of Klucel G used. Air bubbles can be especially noticeable if the paper has been pre-tinted with acrylic paints so as to minimise any wetting and brush-pressure on the cast texture. Using different weights of paper that are light enough to capture a texture but easier to handle should be further experimented.

The properties of the selected paper can also impact the results of paper-based leather fills. In the experiments, the three papers used are made of kozo but paper made from different fibres can act differently when coated in an adhesive. For example, mitsumata paper shrinks more than expands when laminated with sturgeon glue and tends to curl up when dry (Wikarski et al. 2015).

7.1.3 Adhesive

In the experiments, 5%, 10% and 15% Klucel G in ethanol were used for lining the layers of Japanese paper. At 15% the solution is viscous and gel-like and careful application is necessary not to tear the paper, especially when it is thin. As Li (2021) suggests, applying lower concentrations of Klucel G before using the higher concentration can help make handling easier by adding a degree of flexibility.

Quandt (1996) suggests that Klucel J in 50:50 ethanol and acetone makes a more viscous solution that may capture and retain the texture better. The acetone also helps speed up the otherwise long drying time when compared to Klucel G.

7.1.4 Strength and flexibility of fills

Further strength and flexibility testings of both fill types are essential. Girard (2018) conducted a tensile strength test on both adhesive-coated Japanese paper strips and BEVA® 371-based leather strips. Although Girard suggests that the results were not scientifically acceptable due to the large error percentage, the results did show that the tensile strength of the Japanese paper was higher than BEVA® 371. Girard also notes that when the Japanese paper eventually broke it peeled off parts of the original leather, whereas the BEVA® 371 broke across the adhesive. This was not observed in this study as Japanese paper fills still appeared weaker than the BEVA® 371b fills, although coating Japanese paper with Klucel G enhances the strength of the layered fills as evidenced by other authors (Girard 2018; Tkalčec et al. 2016). Further research is needed to evaluate the strengths of these material combinations.

7.2 Making paper fills

This section will suggest changes in manufacture of paper fills to create more flexible and opaque fills which better capture the required texture.

7.2.1 Moulds

Different types of silicone mould materials may be experimented with. Residues should be avoided and it should be noted that no Pinkysil residues were observed during this work.

The silicone used to make a mould must be evenly poured onto the leather surface to avoid warping of the paper fills. Where the object (or similar donor leather) is flat, a piece of glass can be placed onto the silicone to give it a flat surface (Kite & Thomson 2005, p. 128) and if the object is 3D, then a plaster jacket can be used to support and keep the silicone in place (Museum of Fine Arts Boston 2012). However, layering adhesive-coated Japanese paper onto such a mould is likely to produce creases and unsightly overlaps in the paper fill, and the use of lining material is also inhibited as shown in the experiments in this study. In such cases where an object has a very uneven, complex shape, in-situ filling using polymers might be better suited with, for example, further investigation suggested into the use of Paraloid F-10 (Nieuwenhuizen 1998) or acrylic gels to produce textured and shaped fills (Owen & Reidell 2011).

7.2.2 Shaping the paper fill

Because of the pressure applied in paring the edges of a paper fill can affect the fill texture, more exploration of techniques to reduce pressure is required. Paring the fill while retained in the silicone mould proved satisfactory on the one occasion it was used. However, if the mould is to be reused continuously then this is unsustainable as the mould is slippery and scalpel use likely to cause damage to the mould over time. A stable foam-like mat that can disperse the pressure would appear ideal and needs further investigation. Alternatively, experimenting with sandpaper or a damp swab instead of a scalpel as suggested by Reidell and Owen (2011) could also be explored.

7.3 Adhering paper fills

In the experiments, a 5% solution of Klucel G in ethanol was used to adhere the paper-based fill to the leather cover of the fine textured album and 10% Klucel G in ethanol and Lascaux adhesives were used for the paper fills on the coarser textured leather bag. Although the results were successful with strong yet flexible adhesion, experiments with different adhesives would be useful for comparison. For example, Ridley (2017) used wheat starch paste for adhering the paper fills to the synthetic leather Tolex, and Li (2021) used 50:50 wheat starch and EVA in the work with paper fills. It is anticipated that different kinds of leather objects would require different adhesives when applying paper fills.

8. Conclusion

The experiments conducted were designed to test the ability of Japanese paper fills in transferring fine and coarse leather textures and compare these to fills made of BEVA® 371b. Building on previous studies where paper fills were used on rigid leather-like substrates this work also explored if Japanese paper fills can be successfully used on flexible non-rigid leather substrates. Although more defined textures were obtained on BEVA® 371b, lightweight paper fills coated in Klucel G captured both textures in sufficient detail to present an alternative treatment option.

Furthermore, the study revealed that backing paper fills with a lining material adds greater strength and flexibility when compared to the BEVA® 371b fills. This makes Japanese paper fills an attractive alternative for loss compensation in both rigid and non-rigid leather and leather-like substrates.

Given the study presents a set of introductory experiments to on the use of textured Japanese paper fills, as indicated above there are many possible variations for future studies including variations in adhesive choice and application techniques. As such, it is hoped this article provides an insight into a viable alternative for loss compensation in leather objects and spurs others to experiment further with this viable, versatile, non-toxic and sustainable alternative to many of the more commonly used polymers.

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References

Anderson's Bindery 2021a, 'Akaso Kozo 10.5 gsm – Archival', Anderson' s Book Bindery Bookbinding supplies, viewed 27 October 2021, <https://bookbindingaustralia.com.au/product/akaso-kozo-10-5-gsm/>.

Anderson's Bindery 2021b, 'Sekishu Mare 21.4 gsm – Archival', Anderson' s Book Bindery Bookbinding supplies, viewed 27 October 2021 <https://bookbindingaustralia.com.au/product/sekishu-mare-21-4-gsm/>.

Anderson's Bindery 2021c, 'Tengu Paper Extra Light 4gsm', Anderson' s Book Bindery Bookbinding supplies, viewed 27 October 2021 <https://bookbindingaustralia.com.au/product/tengu-paper-extra-light/>.

Barnes n.d., *PINKYSIL skin safe – fast set moulding system RTV silicone rubber, technical data sheet*, NSW, Australia.

Bonnot-Diconne, C, Coural, N & Fabre, M 2001, 'La restauration d'une tenture en cuir peint du musée départemental de Lunéville', *Technè*, vol. 13–14, pp. 141–149.

Berger, G 1972, 'Formulating adhesives for the conservation of paintings', *Studies in Conservation*, vol. 17, pp. 613–629.

Boulton, A 1986, 'The examination, treatment and analysis of a pair of boots from the Aleutian Islands including a note about possible pesticide contamination', *Journal of the American Institute for Conservation*, vol. 25, no. 1, pp. 1–13.

Calnan, C 1991, 'Conservation of leather upholstery on the 1894 Panhard-Levassor motor car at the science Museum', in Calnan, C (ed.), *Conservation of leather in transport collections*, UKIC, London, pp. 31–34.

Chiotasso, L & Costantino, S 2007, 'Conservation of a leather antependium', in Sturge, T (ed.), The conservation of gilt leather, ICOM-CC Interim Meeting, Working Group "Leather and related materials, Brussels, 25–27 March 1998, ICOM-CC, International Council of Museums, Paris, pp. 45–47.

Conservators Products Company (CPC) n.d., '*Announcement: BEVA 371 reformulated in 2010*', viewed 2 October 2024 <https://web.archive.org/web/20240526093914/http://www.conservators-products.com/pro1.htm>.

Down, JL, MacDonald, MA, Tétreault, J & Williams, RS 1996, 'Adhesive testing at the Canadian conservation institute – an evaluation of selected poly(vinyl acetate) and acrylic adhesives', *Studies in Conservation*, vol. 41, no. 1, pp. 19–44.

Fenn, J 1984, 'Some practical aspects in the choice of synthetic resins for the repair of ethnographic skin and gut', *Studies in Conservation*, vol. 29, no. sup. 1, pp. 138–140.

Fulcher, K 2017, 'An investigation of the use of cellulose-based materials to gap-fill wooden Objects', *Studies in Conservation*, vol. 62, no. 4, pp. 210–222.

Girard, S 2018, 'BEVA 371-based synthetic leather - a preliminary investigation on the use of BEVA 371 as a repair material for leather Bindings', *Journal of Paper Conservation*, vol. 19, no. 1, pp. 18–32.

Jutrzenka-Supryn, D & Rosa, H 1995, 'Conservation of a 17th- and 18th-century Polish gala saddle accessories from the Collection of the National Museum in Poznań', in Hallebeek, PB & Mosk, JA (eds.), *Conservation of Leathercraft and Related Objects Interim Meeting on the Treatment of and Research into Leather, in Particular of Ethnographic Objects, Amsterdam*, pp. 109–115.

Kelly KS, Herrmann JK, Chipman A, Davis AR, Khan Y, Loew S, Danzis KM, Ohanyan T, Varga L, Witty A & Youket MH 2020, 'Heat- and solvent-set repair Tissues', *Journal of the American Institute for Conservation*, vol. 61, no. 1, pp. 1–33.

Kite, M & Thomson, R (eds) 2005, *Conservation of leather and related materials*, Routledge, London.

Kronthal, L, Levinson, J, Dignard, C, Chao, E & Down, J 2003, 'Beva 371 and its use as an adhesive for skin and leather repairs: background and a review of treatments', *Journal of the American Institute for Conservation*, vol. 42, no. 2, pp. 341–362.

Larsen, R 1996, 'Deterioration of vegetable tanned leathers', *The Environmental Leather Project*, vol. 12, pp. 1–8.

Li, Y 2021, 'Cast in a different mould: a silicone mould for adding leather grain texture to Japanese paper infills', The Book & Paper Gathering, viewed 25 September 2021 < https://thebookandpapergathering.org/2021/09/23/cast-in-a-different-mould-a-silicone-mould-for-adding-leather-grain-texture-to-japanese-paper-infills/>.

Munn, J 1989, 'Treatment techniques for the vellum covered furniture of Carlo Bugatti', *The Book and Paper Group Annual*, vol. 8, pp. 27–38.

Museum of Fine Arts Boston 2012, 'Conservation in action: Juno, Moldmaking, August 2021', Museum of Fine Arts Boston, viewed on14 October 2021 < https://www.mfa.org/collections/conservation/conservationinaction_juno/moldmaking>.

Nieuwenhuizen, L 1998, 'Synthetic fill materials for skin, leather, and furs', *Journal of the American Institute for Conservation*, vol. 37, no. 1, pp. 135–145.

Owen, G & Reidell, S 2011, 'Cast composites: a system for texturing repair materials in book conservation', *Topics in Photographic Preservation*, vol. 14, pp. 250–262.

Ploeger, R, McGlinchey, CW & René de la Rie, E 2015, 'Original and reformulated BEVA 371: composition and assessment as a consolidant for painted surface', *Studies in Conservation*, vol. 60, no. 4, pp. 217–226.

Poulis, J, Mosleh, Y, Cansell, E, Cimino, D, Ploeger, R, de la Rie, R, McGlinchey, C & Seymour, K 2021, 'Mechanical and physical characterization of natural and synthetic consolidants', *International Journal of Adhesion and Adhesives*, vol. 117, pp. 1–8.

Quandt, AB 1996, 'Recent developments in the conservation of parchment manuscripts', *The Book and Paper Group Annual*, vol. 15, pp. 99–115.

Reidell, S 2019, 'Textured fills: replicating leather surfaces with acrylic media and reusable silicone Molds', in 11th interim Meeting of the International Council of Museum-Conservation Committee (ICOM-CC) - Leather and Related Materials Working Group, International Council of Museums, Paris, pp. 138–144.

Ridley, C 2017, 'Conserving with Japanese tissue: beyond books and paper, Part 1', The Book & Paper Gathering, viewed 27 October 2021 <https://thebookandpapergathering.org/2017/04/06/conserving-with-japanese-tissue-beyond-books-and-paper-part-1/>.

Rivers, S & Umney, N 2003, *Conservation of furniture*, Routledge, London.

TALAS1 n.d., 'Beva 371 solution', TALAS Conservation, Archival & Bookbinding Supplies, viewed 14 October 2023 <https://www.talasonline.com/Beva-371-Solution-Gallon>.

TALAS2, n.d., 'Klucel G & E Hydroxypropylcellulose', TALAS Conservation, Archival & Bookbinding Supplies, viewed on 24 October 2021 <https://www.talasonline.com/Klucel-G>.

Tkalčec, MM, Bistričić, L & Leskovac, M 2016, 'Influence of adhesive layer on the stability of kozo paper', *Cellulose*, vol. 23, pp. 853–872.

Wikarski, J, Eyb-Green, S & Baatz, W 2015, 'Filling in losses in parchment bound volumes – part II: comparing infill materials with regard to their climate stability and their application in the spine Area', *Restaur*, vol. 36, no. 1, pp. 47–79.