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Use of magnetic sheets in vertical deformation treatment of textile supports of contemporary paintings

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Abstract: The practice developed during a conservation and restoration intervention does not always follow common or traditional standards, whether due to technical limitations, or space constraints related to the size of the works, or by the material requirements that the works themselves can present. In the light of various particularities and needs, research was initiated into the use of harmless and satisfactory methods in the occasional treatment of deformations of the support of contemporary pictorial works, using magnetic sheets. In its use, different valences were evaluated, such as the control in the iteration of the work, the effectiveness and control of humidity and time during the performance of the treatments, and the results obtained. This article will reflect on the process developed with the application of four case studies, presenting the advantages and disadvantages in the use of this method.

Keywords: contemporary painting, textile support, deformation, flattening, vertical treatment, magnetic system, magnetic sheets

El uso de hojas magnéticas en el tratamiento vertical de deformaciones puntuales de los soportes textiles de pinturas contemporáneas

Resumen: La práctica desarrollada a lo largo de una intervención de conservación y restauración no siempre sigue estándares comunes o tradicionales, ya sea por limitaciones técnicas, así como de espacio con correlación con el tamaño de las obras, o por los requisitos materiales que las propias obras pueden presentar. Fue ante varias particularidades y necesidades, que se inició la exploración del uso de métodos inocuos y satisfactorios en los tratamientos puntuales de deformaciones del soporte textil de obras pictóricas contemporáneas, utilizando láminas magnéticas. En su uso se evaluaron diferentes valencias, como el control en la iteración con la obra, la eficacia y control de humedad y tiempo durante la realización de los tratamientos, los resultados obtenidos y su eficacia. Este artículo reflejará el proceso desarrollado con la aplicación a cuatro casos prácticos, presentando las ventajas y desventajas en el uso de este método.

Palabras clave: pintura contemporánea, soporte textil, deformación, planificación, tratamiento en la vertical, sistema magnético, láminas magnéticas

O uso de folhas magnéticas no tratamento vertical de deformações pontuais dos suportes têxteis de pinturas contemporâneas

Resumo: A prática desenvolvida ao longo de uma intervenção de conservação e restauro nem sempre segue os padrões comuns ou tradicionais, quer por limitações técnicas, como de espaço com correlação com a dimensão das obras, quer pelas exigências materiais que as próprias obras podem apresentar. Foi perante diversas particularidade e necessidades, que foi iniciada a exploração da utilização de métodos inócuos e inovadores nos tratamentos pontuais de deformações do suporte de obras pictóricas contemporâneas, com recurso a folhas magnéticas. Na sua utilização foram avaliadas diferentes valências, como o controle na iteração com a obra, a eficácia e controle de humidade e tempo durante a realização dos tratamentos e os resultados obtidos. O presente artigo refletirá o processo desenvolvido com a aplicação a quatro casos de estudo, apresentando as vantagens e desvantagens na utilização deste método.

Palavras-chave: pintura contemporânea, suporte têxtil, deformação, planificação, tratamento na vertical, sistema magnético, folhas magnéticas

Introduction and contextualization

In order to present the object of study and the field of action, it is important to mention that this article will focus on the applicability of the treatments to contemporary paintings on textile supports, with the need to correct alterations and damages, such as local deformations in the supports, resulting from mechanical actions by impact or external pressure. Although the system presented here can be applied to other supports, such as paper or other types of paintings [1], for instance, the methods and procedures will only be developed and presented only on four case studies of contemporary paintings.

Following the principle of minimal intervention, a process of reflection on the procedures and methods used in the treatment of the correction of local deformations present in contemporary painting was initiated. The theoretical questioning establishes an inescapable relationship with the problems and limitations presented by contemporary pictorial works, in which the large size of contemporary works is generally a factor demarcated by damage and alterations associated with handling or transport phases, so that mechanical impacts resulting from the direct action of a rigid surface with the support, often result in tears, deformations of the textile supports, as well as, by the extent of the damage and its interdependence with common performance practices.

Knowing that deformation is a phenomenon of alteration of the original aspect/form of a body, in a painting on canvas it can be the result of actions and forces of excessive stretching or tension (Giannini and Roani 2003: 67), due to factors related to the process of execution, from the use, or from accidents, impacts, pressures or incorrect actions or conservation conditions (Calvo 2003: 74). This physical-mechanical alteration of the support, and consequently of the preparation and the pictorial layers, can manifest itself in the form of cracks and lifting. Faced with such changes and damage, the inevitable path will be to restore the original aspect and forms using flattening treatments in the case of the supports and fixing in the case of the layers. It is worth noting here that, "it is rarely specified that a painting on canvas is stretched, yet this is one of the most significant aspects. Canvases are stretched and attached to an open wood framework consisting of at least four members fixed together at the corners" (Hackney 2020: 6). The knowledge of the entire stretching process is fundamental, as it has consequences on the fibres and the structure of the substrate if the tension is not well distributed, without neglecting the behavioural differences between the different fibre types, textures and properties, dimensions, as well as the role and influence of the underlying layers on the substrate. In this context, it is equally important to establish a relationship between stress and strain: "The term stress is defined as a force per unit area and the term strain as the percentage extension induced over original length. They are defined in this way to allow the mechanical properties of different materials to be compared independently of dimensions (Hackney 2020: 94-95). According to Hooke's law, an elastic material is more properly defined as one that, when stressed repeatedly behaves linearly, and when the stress is removed, the material returns to its original length (zero strain) (Hackney 2020: 95-96). As a result of its uneven behaviour in different dimensions, canvas is considered a material anisotropic, "since weft and warp are not identical, and canvas is very much less stiff in the bias (45º) direction" (Hackney 2020: 96)

When thinking about the process of eliminating deformations, actions of humidification are associated with different methods, such as, "(...) by contact of moistened drying papers, by pulverisation or impregnation, by lining with flour paste and glue, and more recently with suction tables or humidity chambers, with variants of applying weight, heat or suction at the moment when the canvas acquires the necessary flexibility" (Calvo 2003: 198). Deliberating over the design of a treatment for a flexible and hygroscopic support means considering the use of a flat surface that allows the support to be treated correctly and effectively. As stated in the book *Restauración de obras de arte: pintura de caballete:* "Deformations are changes in the shape of the surface of a painting. If they are small bulges caused by the loss of tension in the canvas, an effective method is to re-tension it with the correct insertion of wedges in the frame boxes or with the addition of some moisture and treatment on the suction table" (Sánchez 2012: 96). Although the publication *Conserving Canvas* is very focused on issues of support enhancement, it also presents various contributions in the context of structural treatments and innovative approaches (Schwarz, *et al.* 2023), but these are not referenced as they do not focus on the issues raised in this article in relation to flattening treatments.

In the case of large works, however, there are limitations and problems in carrying out what appears to be a simple and controllable treatment: on the one hand, the very size of the paintings and some characteristics of the support, such as thin supports or those that are very susceptible to physical or mechanical changes, either due to the lack of preparation or to the quality of the thread or the specific characteristics of the layers, which limit the manipulation and placement of the works according to orientations/positions that are contrary to their vertical orientation, not to mention that an irregular or textured pictorial surface automatically makes it impossible to place it on a flat surface facing downwards; and, on the other hand, problems related to the equipment, which often does not have the necessary and sufficient dimensions to handle the size of the works. In addition to these facts, there are other problems associated with flattening treatments, such as the fact that it is not necessary to lay down the work, making it an excessive treatment for the damage presented.

Traditionally, when the support shows slight and localised deformations due to mechanical impact, the treatment consists of the application of moisture and the application of controlled pressure (Sánchez 2012: 96); as described by the author, the treatment consists of dismantling the frame fabric, placing the painting face down so as to slightly moisten the support in the affected area, and placing weights in a wider area than the treated one (Sánchez 2012: 96). Reinforcing this procedure, Calvo states that small deformations caused by distortions of the canvas will be resolved using the tensioning system built into the frame, while small deformations of slight dimensions or points caused by pressure or mechanical shock will be corrected using a very small amount of humidity and weight, without dismantling the canvas from the frame, and preferably using a mini suction table (Calvo 2003: 199).

Starting from the principle that conservation and restoration interventions should be minimal, in order to limit unnecessary interventions on the work, thinking about solutions for the removal of paintings with minor damage related to the support means initiating a process of balance between the needs presented by the work and the steps and consequences of the treatments themselves. It was the search for a balance between the dimensions of the damage and the consequences of the treatments, and the various constraints associated with the characteristics of contemporary paintings with clear evidence of large dimensions, that led to the search for a solution that would allow the restoration of the flat shape of the support or of the layers without resorting to treatments that could not be considered minimal. The process of removing the frame, which includes extracting the elements that attach the canvas to the frame, is an operation that has a major impact on a painting; and even in the case of textile supports, which are often still strong, stable and elastic, it is completely avoidable, as it is in the context of interventions on contemporary paintings when there are no other underlying treatments that involve removing their frames. When assessing the consequences of the intervention, the change in the state of a painting is clearly perceptible: from tensioned or semi-tensioned, when the textile support had been showing signs of stretching, to a state of total relaxation. Occasional stretching could be considered, but even this should be avoided if at all possible because of the changes associated with the intermittent relaxation and differentiated tensioning of the forces applied during the previous retraction. Such changes in condition have obvious consequences to the work when most of the problems encountered in paintings on canvas are related to the tension and stretching of the supports, which contribute to mechanical fatigue, and are very difficult to control in the face of changing environmental factors, especially humidity. Alterations and damage are also present in the field of contemporary painting, with consequences very similar to those of traditional paintings.

However, the size of the work is not only one of the main factors leading to the probable presence of a greater number of alterations and damages, as mentioned above, but also a limiting factor when it comes to carrying out a conservation-restoration intervention: in practice, it is the difficult to find an answer in terms of the working space itself, which is often limited, requiring the use of large equipment, or limiting the intervention to a single work, regardless of the size and importance of the damage present in the painting, so that it would be very useful and effective if the treatment of deformations in the support of large paintings could be carried out vertically.

In practice, however, there are other obvious limitations linked to the characteristics of the work and the areas of intervention, such as the inaccessibility of equipment capable of providing an effective response in terms of treatment, such as mini suction tables with articulated arms that allow work to be carried out vertically. With knowledge of the characteristics and capabilities of suction tables, it is clear that the problems presented could be solved, either by providing a temperature, suction, or vacuum system, or by possibly working on cramped spaces. In the article by Markevičius, T., *et al*. (2017), several treatment systems for paintings are presented, among which the treatment of the vertical deformation of the painting *Open No. 16* by Robert Motherwell stands out. For reasons related to the enormity and fragility of the work, the treatment was carried out vertically in order to allow access from both sides, using heat. In this treatment, we highlight the portability of the system, which made it possible to work on site, the size of the equipment, slightly larger than the damage presented, and the characteristics and properties of the system and equipment that allowed access to the area and controlled temperature transfer.

Based on the knowledge of the tools and methods presented and the impossibility or limitation of access to certain equipment, whether due to specificity or insufficient dimensions, a treatment solution was tested and evaluated with the aim of overcoming all these problems, which consisted of the use of magnetic sheets.

Brief overview of the use of magnetic systems in the context of conservation and restoration

When the research related to magnetic systems in the field of conservation and restoration began, relatively recent publications appeared, with different methods of application and with different functions, such as the cleaning systems through nanomagnetic sponges (Bonini *et al.* 2007), the development of a technique using magnets as part of a long-term treatment for an artwork with metal components (Adsit 2011), the alternative methods in the reconstruction of the shape and the union of parts of a sculpture (Rodríguez et al 2018), or the mounting and display systems of the works through the use of magnets in the vertical subjection of the pieces (Spicer 2019). In 2016, Spicer published an article in which she explains the physics of magnets, their characteristics, their use, and the issues of storage and durability—fundamental issues to be considered when using magnetic systems in works of art.

In the context of the increasing use of magnetic systems in the conservation of works of art, Zuzanna Szozda (2021), in "The Impact of Magnets on Certain Pigments and Paints Used in the Conservation of Paintings and Works of Art", warns against the use of permanent magnets in works of art and their relationship with certain pigments present in the pictorial layers. The author concludes: "since many substances used in the process of creation and conservation of works of art react to magnetic stationary and alternating fields, it would be reasonable to classify pigments and particles by a measure other than just qualitative. To ensure magnets are used safely in conservation studios and museums, it is crucial to obtain the magnetic characteristics X = f(H) (...) and to properly classify pigments, mediums, paints, and other substances used into the following groups: ferromagnetic, ferrimagnetic, and paramagnetic (...) as well as diamagnetic materials" (Szozda 2021: 5).

Regarding the use of magnetic systems for the treatment of textile supports, it is worth mentioning the research developed by Sterp Moga and Sánches Ortiz (2019) where they presented a deformation correction system using an auxiliary frame with a magnetic system. In the article, the advantages of using the magnetic system to correct deformations and control the tension of the textile support are evident, with the authors concluding that "the use of BASM makes it possible to minimise the manipulation of the frame, avoids having to resort to other more invasive methods during conservation-restoration treatments and guarantees a fully retractable procedure. For all these reasons, it is considered to be a tool that can offer the restorer effective and respectful options with the original" (Sterp and Sánchez 2019: 74).

The same authors, Sterp and Sánchez, published in 2022 the article "Neodymium Magnets as a Minimal Intervention Alternative to Traditional Treatments for Fixing Paint on Contemporary Paintings", in which they presented "an alternative method to traditional procedures for fixing colour and preparation layers in contemporary two-dimensional painting based on the use of neodymium magnets" (Sterp and Sánchez 2022: 1). The article details the tests carried out, the different characteristics of the works and methods used, and the results obtained, with the authors concluding that "the use of magnetic systems for the fixation of pictorial layers has proven to be an effective alternative, because it allows one to minimize the manipulation of the work and treat a very localized area. This procedure avoids the need to resort to other more invasive methods during conservation-restoration treatments. Its application is very fast, and dismantling does not imply any risk if they are properly removed" (Sterp and Sánchez 2022: 8). In 2023, the authors published "Magnetic Systems as an Alternative to Traditional Methods for the Conservation-Restoration of Painted Canvas Supports: A Proposal of Minimal Intervention Protocols", concluding that the tests validated the use of neodymium magnets as an alternative to traditional methods, as well as allowing treatments to be carried out of sutures thread-by-thread or using textile intarsia, or thread-bridge, thus reducing handling and associated risks. (Sterp and Sánchez 2023)

Use of magnetic sheets for vertical deformation treatment of the textile supports of four contemporary paintings

Magnetic sheeting, or flexible magnet or magnetic rubber, is a material made up of rubber and ferrite powder [2], or a magnetic material and a mixture of polymers and other materials, which makes it flexible and durable [3], with variable dimensions, thickness, and magnetic forces, with adsorption on one side. "The most commonly used ferrites (Fe ions) are barium or strontium based (...) and have high thermal stability and consist of a low-cost product whose magnetic properties are satisfactory" (Emura 1999: 4). Regarding agglomerated magnets, which belong to the class of permanent magnets, "they are composite materials formed by a magnetic phase dispersed in a polymeric matrix. Since the magnetic phase is diluted in a non-magnetic matrix, their properties are inferior to conventional magnets. They have mechanical advantages in both forming and strength. Varying the ratio between the amount of polymer and magnetic powder allows better control of magnetic or mechanical properties in their final application" (Emura 1999: 7). "The volume fraction between powder and binder is determined by the manufacturing process, which can be by calendaring, extrusion, compression and injection (…). In the calendaring process (...), the material passes between rollers, forming a sheet that can reach tens of meters in length and thickness between 0.3 to 6 mm (...). The calendaring and injection processes use a volumetric fraction of magnetic powder of maximum 70%, the rest (30% in volume) is complemented by the binder. This amount of binder is necessary to give strength and flexibility to the calendared material (...)" (Emura 1999: 12-13). "In compression moulding (...), the powder is mixed with the binder and compacted under pressures of up to 50 tonne per square inch (...). The compacted product is then cured at temperatures between 150 and 175°C. The volume fraction is about 80%, resulting in a material with better magnetic properties than the other processes" (Emura 1999: 13).

The magnetic sheets used are flexible and can be used for a variety of purposes. Some have double-sided tape on one side and can be easily cut with scissors or a box cutter. They are cheap and easy to obtain, their manufacturing process, however, is unknown.

For the present study, three sizes of magnetic sheets were used: the larger ones which measure 21 cm x 29.7 cm, with thicknesses between 0.7 mm and 0.4 mm, and weight between 165 gr and 103 gr, respectively; the medium ones with 12 cm x 17 cm, 0.5 mm thickness, and 54 gr of weight, and the small ones with 6.5 cm x 4.5 cm, 0.8 mm thickness, and 8 gr of weight.

Force and pressure tests were carried out to assess the tensile strength of the magnetic sheets when applied to painted textile backings [Table 1]. The magnetic sheets were cut into 5 cm squares and then glued to chipboard parallelepipeds.

The tests were carried out on three magnetic sheets with different thicknesses: 0.4 mm (A), 0.7 mm (B), and 0.8 mm (C). Six tests were carried out for each thickness: on the one hand, by varying the number of magnetic sheets (two, one on each side of the support/painting; or four, two on each side of the support/painting, to test the strength through by overlapping); and, on the other hand, by varying the support/painting (a support with preparation; a support with preparation and image layer; a support with preparation and image layer with texture), with the aim of understanding the difference between the different thicknesses and textures and the force/pressure exercised. The tensile test to determine the internal bond strength was carried out in a universal testing machine Tinius Olsen, H5KS. A method device described in the standard EN 319 Particleboards and Fibreboards was used: Determination of tensile strength perpendicular to the plane of the board. The test method described in this European standard is equivalent to ISO 16984:2003 Wood-based panels — Determination of tensile strength perpendicular to the plane of the panel. [Figure 2]

Sheets magnetic	Number of sheets	Support/ painting	Force (N)	Weight (g)
A	1+1	1	1,33	133
A	2+2	1	1,67	167
A	1+1	2	1,33	133
A	2+2	2	1,67	167
A	1+1	3	1	100
A	2+2	3	1	100
B	1+1	1	2,67	267
B	2+2	1	5,33	533
B	1+1	2	3	300
B	2+2	2	3,67	367
B	1+1	3	2	200
B	2+2	3	3,67	367
C	1+1	1	5	500
C	2+2	1	8	800
C	1+1	2	3,67	367
C	2+2	2	6,67	667
C	1+1	3	2	200
C	2+2	3	4,33	433

Table 1.- Tensile strength test results with various magnetic sheets and supports.

Figure 1.- Tensile strength test results with various magnetic sheets and supports.

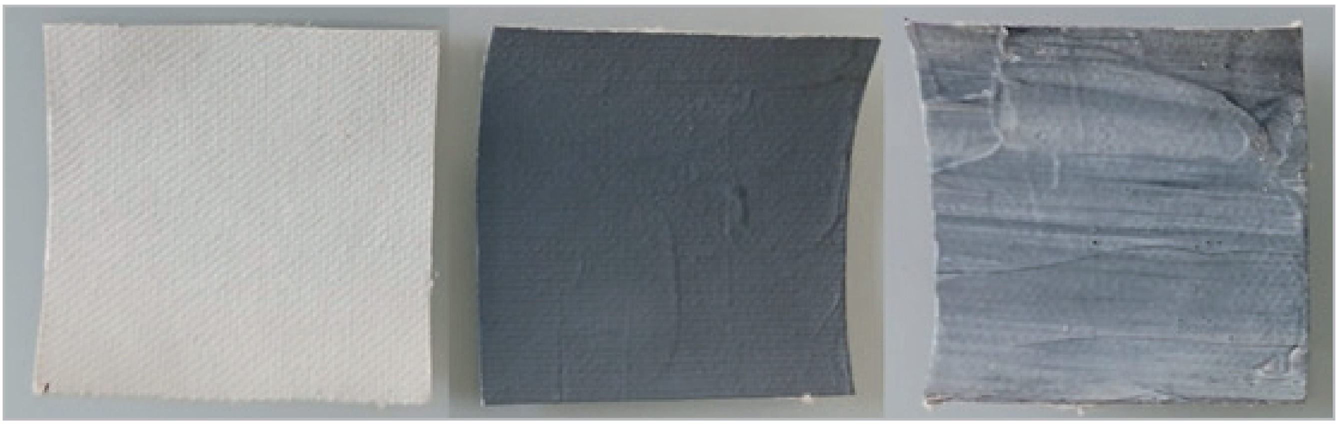

Figure 2.- The textile supports used to test tensile strength.

The results of the 0.4mm plate were identical between sample 1 (support with preparation) and sample 2 (support, preparation, and image layer), regardless of the number of magnetic sheets, 2 or 4. The results obtained with sample 3 (support, preparation, and image layer with texture) were identical in terms of tensile force when 2 or 4 magnetic sheets were used.

The force exerted with 4 magnetic sheets on sample 1 (support with preparation) is almost twice as high as that exerted with the 4 magnetic sheets; this force decreases considerably when the sample has an additional layer (sample 2: support, preparation, and image layer), with the tensile force of 3.67N remaining identical when sample 3 (support, preparation, and image layer with texture) is tested. It should be noted that the results with 2 magnetic sheets do not reflect the same variables.

Finally, the force exerted by sample 1 (support with preparation) is significantly higher than the other four tests with the 0.8mm magnetic sheets. However, the difference between the forces exerted by the 4 magnetic sheets decreases according to the number of layers that make up the samples and when compared with the forces exerted by two magnetic sheets: the tension is 1.6 times lower for sample 1, 1.8 times lower for sample 2 and 2.1 times lower for sample 3.

In the overall analysis of the results obtained with this stress test, it is not possible to establish a relationship between the different samples and the number of magnetic sheets since they do not show uniform percentage equivalents.

With regard to the practical applicability of the experiments, the four selected works date from between 1999 and 2003 and present support deformations with different and varied characteristics and dimensions, mainly due to excessive tensions on the support resulting in fibre distension. The diversity of the supports and of the preparation and paint layers was also taken into account in order to evaluate the process and the treatment itself, as well as the results obtained.

The works selected to carry out and test the methods and processes of design treatment of the textile supports on were:

a. Oil painting on cotton canvas with manual preparation, with dimensions 50.5 cm x 30.5 cm. The painting showed two deformations: one, on the right side of the central area, resulting from the bending of the support and, consequently, of the preparatory and chromatic layers, before the work was created; and a second deformation, resulting from the pressure exerted by the back on an uneven surface, causing a deformation with a height of approximately 2 cm. This deformation was located in the right lateral area, where part of the deformation was in the area of the frame [Figure 3, Figure 6].

b. Oil painting on industrially prepared cotton and linen canvas, measuring 60 cm x 73 cm. The painting showed two concave deformations near the upper right corner due to the pressure from the front of the painting, with a maximum diameter of approximately 0.5 cm; and a third deformation of rectangular shape with rounded

Figure 3.- Case study a., oil painting on manually prepared cotton canvas (©author)

Figure 4.- Case study b., oil painting on cotton and linen canvas prepared industrially (©author)

Figure 5.- Case study c., acrylic painting on industrially prepared canvas, varnished (©author)

corners, measuring 27 cm x 31 cm. This deformation was the result of improper storage and was located in the lower left quarter; there was also a deformation caused by contact with the frame on the lower left side [Figure 4].

c. Acrylic painting on industrially prepared canvas, varnished, measuring 60 cm x 80 cm. The painting showed several deformations, folds, and wrinkles in the support, due to an incorrect packing and storage system. The work had probably been rolled, and the folds and changes in the backing were regular in both directions, vertically and horizontally. The painting was created without prior correction of the deformations [Figure 5].

Photographs were taken before, during, and after the treatments, using shallow lighting, in order to record and evaluate the progress and effectiveness of the treatments carried out. The support flattening treatments to correct the deformations were carried out with the works in a vertical position, in the following order:

1. Occasional and reduced humidification with a nebuliser. The process of humidifying the supports was quantified by counting the consumption of 10 ml of distilled water in the form of vapour when carrying out the three treatments described. The humidity chamber system was used in two situations [Figure 7].

2. Place the magnetic sheets: first place the sheet on the back of the work and then place the sheet on the front of the work. The magnetic sheet applied to the front should be accompanied by a protective cover, such as a Reemay® sheet, or other similar material, to protect the image surface and avoid direct contact between the image surface and the magnetic material [Figure 8, Figure 9].

3. Time control by monitoring and evaluating the results obtained. The effectiveness of the treatment was assessed by visual comparison, direct observation, and analysis of photographic records.

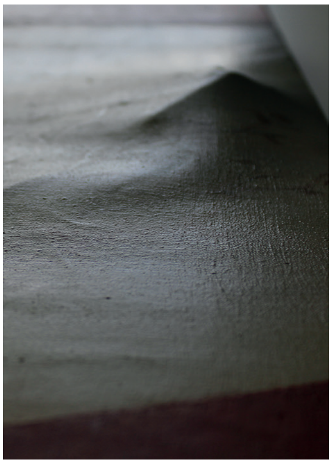

Figure 6.- Detail of the deformation of the support (©author)

Figure 7.- Detail of the deformation of the support (©author)

Figure 8.- Front of painting with the 21 x 29.7 cm magnetic sheet applied (©author)

Figure 9.- The back of the work, with the application of two magnetic sheets, with one of the sheets partly under the frame. (©author)

The treatments were carried out in the order above and this stage describes the process and the controls in place.

For the oil painting on cotton canvas with manual preparation, with regard to the size of the deformations, the medium size magnetic sheets (12 x17 cm) were used. After applying moisture, two magnetic sheets were placed, one on each side. The first check was carried out after 30 minutes: the deformation due to the bending of the support and the layers was almost corrected; the deformation of 2 cm height was quite flat, but with several waves and circular folds in the support. From this evaluation, it was concluded that the deformation could probably be corrected by increasing the pressure without having to increase the humidity again. With this in mind, the magnetic sheets were reapplied, in this case using four sheets until the drying process was complete: two sheets on each side. A new visual inspection was carried out after 1 hour and a slight waviness of the support was noted, despite the obvious correction of the deformation. To increase the flexibility of the backing, moisture was again applied to the area of deformation and five magnetic sheets were placed, two overlapping on the back and three overlapping on the front of the paint. After 30 minutes, a new inspection was carried out and a correction of the entire deformation was observed. To ensure the effectiveness of the treatment, two magnetic sheets were applied again, one on each side, until 1 hour had elapsed.

The treatment of the oil painting on industrially prepared cotton and linen canvas began with the correction of small deformations located in the upper area. The process consisted of the application of moisture and the placement of six small magnetic sheets (6.5 x 4.5 cm), one sheet on each side in the case of the rightmost deformation and two sheets on each side in the case of the leftmost deformation. This choice was made taking into account the characteristics of the deformation, since deformation on the right side contained a tear, so that the movement of the fibres would require less pressure as the support was more relaxed. After 10 minutes the first visual inspection was made and, in both cases, an almost complete correction of the surface was noted. The magnetic sheets were reapplied and the treatment was completed after 1 hour [Figure 10].

For the rectangular deformation, humidity was applied through a humidity chamber system to ensure a homogeneous and regular distribution over the entire deformed surface, followed by the placement of six larger magnetic sheets (21 x 29.7 cm), with an overlap of two on each side, and two medium-sized magnetic sheets (12 x 17 cm). The first control was carried out after 30 minutes, where the total correction of the vertical deformations was visible. The lower horizontal deformation still showed a slight mark, with a large mark in the corner area, with a slight waviness (area of greatest deformation), demonstrating the need to place a reinforcement of sheets in this area. In the upper deformation there was still a slight change in the support. A new localized application of moisture was made in these two areas and eight larger magnetic sheets were placed, overlapping in both places by 2+2 on each side. A further check was made after 30 minutes and only slight deformation was observed in the corner areas of the rectangle, after which the eight magnetic sheets were reapplied, ensuring complete correction of the support after a further 1 hour of treatment [Figure 11].

In order to correct the deformations present in the acrylic painting, two tests were carried out on the industrially prepared paint and varnish painting: one with occasional moistening of the support, and a second without moistening. In both cases, the largest magnetic sheets (21 x 29.7 cm) were used. For the humidified area, two sheets were placed, one on each side, and for the non-humidified area, four sheets were placed, two on each side. After 30 minutes the control was carried out and it was concluded that in the humidified area, the flattening had been effective; and in the non-humidified area, the correction of the deformation was clear, without the process being completed. The magnetic sheets were repositioned and a new visual check was carried out after one hour and the complete flattening of both zones was visible. In view of the results, it was decided to treat the remaining areas without humidification, even though the role and function of this process and the role of humidity are clear, since "it is precisely thanks to the contribution of humidity on the surface of the back of the painting that it is possible for the fabric to recover its lost equilibrium: the water mist expands it if it is prepared with animal glues, creating a strong shrinking tension in the unprepared canvases (...). In a second phase a shrinkage will be obtained in a first case and, in a second, a relaxation of the fabric" (Sánchez Ortiz 2012: 96). However, depending on the ageing of the support, "a canvas gradually relaxes, losing tension as it attains its stretched dimensions. At higher humidity (50%-80% RH), the canvas can become larger than its support and begin to sag, exhibiting a characteristic concave belly from resting on the lower member" (Hackney 2020: 21).

Taking into account the scientific and technical knowledge related to the behaviour of materials in the presence of humidity, and considering that the characteristics and composition of the support and its durability are very important, and that the deformations did not imply a loss of elasticity or breakage of the fibres, it was decided to carry out the treatment without the use of humification and it was found that the treatment was equally effective in returning the substrate and underlying layers to a non-deformed state. [Figure 12]. In the first two cases, the application of moisture was critical as textile substrates shrink significantly when in contact with high RH levels. Pierce and Collins' initial investigations into the shrinkage of cotton showed that "as moisture is absorbed, the woven yarns expand laterally, increasing the distance the warp has to expand around the weft, and vice versa. At high RH, when water absorption is at its greatest, the warp yarns have to stretch around greatly swollen weft yarns, and this effect exceeds the longitudinal swelling from water absorption. The result is that the weave geometry is tightened and the cloth shrinks." (Hackney 2020: 102). Returning to the decision-making process for the case studies, both had high levels of deformation without fibre breakage, making the application of moisture inevitable for their treatment. Compared to the condition of the fibres and the deformations in the third case study, the deformations were of shape, i.e. the support went from flat to a state of punctual deformations, deformations that were not the result of the fibres distending, but of a simple change in shape, from flat to the presence of irregularities in the structure.

After carrying out the vertical treatment on the deformations present in the three contemporary paintings, a new test was carried out, different from one of the previous requirements where the treatment was carried out vertically, but which provides extremely positive data, contributing information of interest and exchange. The treatment was carried out on an acrylic painting on industrially prepared canvas, measuring 27 x 22 cm [Figure 13]. The layer of the lower part of the painting was applied with a spatula, showing some relief. The work was rolled up with the chromatic layer on the inside. It was not possible to open and view the painting without the application of humidity, so the first step was to humidify it using the humidity chamber system [Figure 14 and 15]. After humidifying the support and the chromatic layer with 2 ml of distilled water, two magnetic sheets of larger size (21 x 29.7cm) and thinner thickness (0.4 mm) were placed in order to apply some pressure, slowly and able to adapt to the forces of the support and the layers [Figures 16 and 17]. After 5 minutes, when the sandwich system was quite flat, two more magnetic sheets of the same size but thicker (0.7 mm) were placed. The first check was carried out after 30 minutes and the support was flattened, with a slight deformation in the areas of breakage of the chromatic layer in the textured area. The magnetic sheets were repositioned and a new visual check was carried out after 1 hour to check the flatness of the support as a whole [Figure 18].

This fourth experiment strengthened the control of the treatment with the magnetic sheets, but above all it demonstrated their practicality. The treatment described could certainly have been carried out using traditional methods, given the small size and lack of frame, but perhaps obtaining satisfactory results, although identical, would have taken longer or required a greater increase in humidity. The fact that the thinner magnetic sheets adapt to the shapes of the supports and the layers not only facilitates the treatment process but also speeds it up, avoiding the need for staging: application of moisture and treatment by parts. The malleability and flexibility of the sheets is a clear advantage in this case.

Figure 10.- Detailed record of case study a., after treatment. (©author)

Figure 11.- Detailed record of case study b., after treatment. (©author)

Figure 12.- Detailed record of case study c., after treatment. (©author)

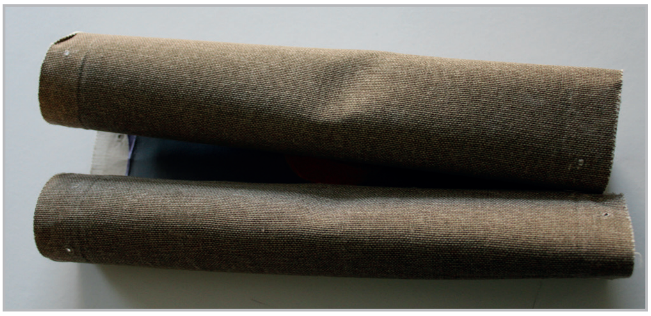

Figure 13.- Fourth case study before flattening. (©author

Figure 14.- First phase of moisture application. (©author)

Figure 15.- Second stage of humidification, already with semi-flat screen. (©author)

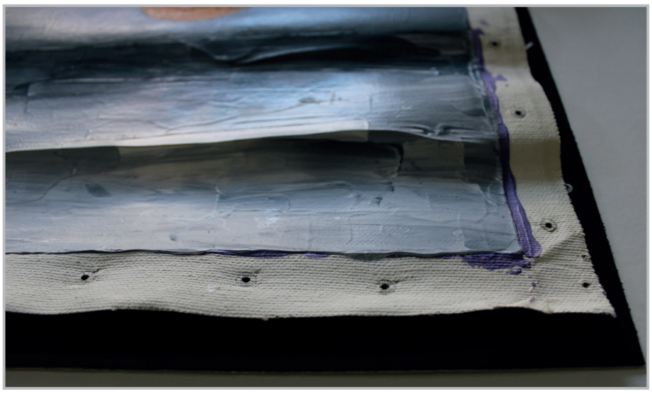

Figure 16.- Placing the magnetic sheets under the paintwork. (©author)

Figure 17.- Applying magnetic sheets to the front of a painting with Reemay® image layer protection. (©author)

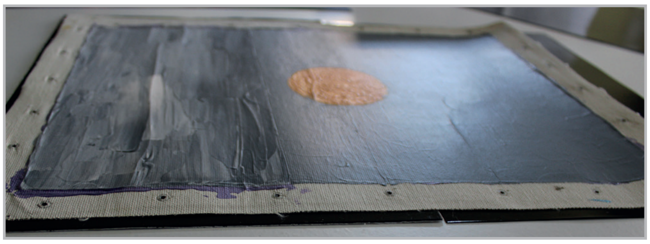

Figure 18.- Lateral registration after flattening. (©author)

Figure 19.- Frontal registration after flattening. (©author)

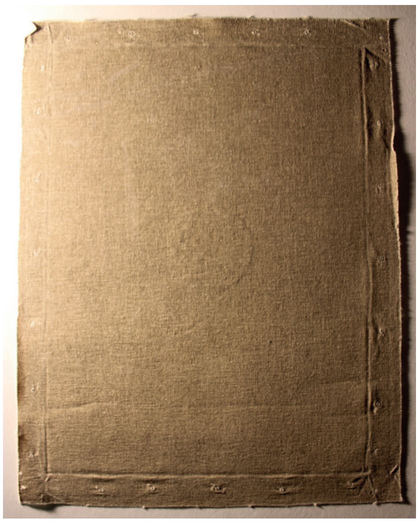

Figure 20.- Back registration after flattening. (©author)

Conclusions

Returning to the central theme, the treatment of deformations with the works in a vertical position, it is possible to conclude the effectiveness of the same with recourse to the magnetic system through the use of magnetic sheets. This confirms the clear response to the needs initially identified, such as the possibility of bypassing the treatment of large works without having to place them in a horizontal position using large tables; the effectiveness of vertical treatment without having to use expensive equipment that is often inaccessible to a large number of technicians. To these positive points must be added the speed of treatment and the reduction in the amount of moisture needed to correct damage or alterations, as well as the ease of obtaining magnetic sheets, the cost efficiency, and the possibility of finding sheets of different sizes and thicknesses.

As mentioned by Sterp and Sánchez (2022: 8), this system also has advantages in areas that are difficult to access, as it can be used between the support and the frame. As such, it is an extremely positive advantage, since it allows the treatment and correct deformations found in the area of the frames and the rafters, which would otherwise have to be treated horizontally: the use of a system that is less than 1 cm thick, which creates pressure between the parts and achieves the desired results, is undoubtedly remarkable. To this characteristic we can add the reduced weight of the sheets themselves: the fact that this is a vertical treatment must be taken into account. Obviously, the magnetic forces distribute and to a certain extent eliminate the tension on the support, since the same forces make the external elements, the magnetic sheets, self-supporting between themselves or autonomous when joined together, reducing the tension on the support or layers. The same authors, in 2023, state that "It is important to remember that the method of assembly of the magnetic system, the holding and tension force, and the size and weight of the magnets are factors that must be evaluated by the restorer. This method is simple, low-cost, effective, reversible, and respectful of the original work of art."

The magnetic plates allow pressure to be exerted on the surfaces, but at the same time, they allow the support and the underlying layers to be moved between the plates, so that flattening can be carried out with little or no humidity, depending on the degree of ageing and/or degradation of the materials and the size of the damage. This description contradicts what happens when a vacuum table is used for flattening: the treatment is the result of a pressure action exerted on the support and its layers, where one of the faces is immobilised by the suction action and consequently the vacuum, and the materials must necessarily be flexible and elastic so that they respond quickly to the change in shape inherent in the process itself. In these situations, flattening should normally be carried out using humidification - which favours the adaptation of the surfaces and increases the flexibility of the materials - and pressure - which maintains the position of the material - with the addition of heat, which speeds up the whole process.

However, the use of magnetic sheets also has its drawbacks: since the traction created between the magnetic sheets is reduced, as observed in the tensile tests, although it is sufficient for the case studies presented, it may be limited for thicker substrates and/or layers, and its limitation is clear when dealing with highly textured surfaces. Another drawback identified is the lack of information on technical and compositional issues; in this sense, contact was made by e-mail with one of the companies selling the material, and the reply was that such information could not be shared.

This exposure should be considered as the result of an experimental study, which deserves a deeper understanding of the behaviour of fabrics, taking into account that the behaviour is variable when the fabric is stretched and deformed on a grid, or when flattening is carried without removed the grid, taking into account the orthogonal directions of the weft and warp and the relationship established between longitudinal elongation and transverse shrinkage (Hackney 2020: 99). As a result, the system should be subjected to more rigorous and scientific validation through measurements of support tension, changes in the fabric or associated deformations.

Finally, it is important to mention the need for constant observation and control in the use of this magnetic system, referring to the questions raised by Szozda (2021), emphasising that the short periods in which the desired results are obtained is a favourable factor for the use of magnetic sheets, as a localized and non-permanent system, without interfering with the composition and characteristics of the pigments.

As with the usual treatments used in the flattening of textile supports, the verification of the correction of deformation is empirical, based on experience gained, and it is easy to prove its effectiveness by direct visual assessment, supplemented by visual assessment in low light. Full verification will take place in the medium term, with the consequent loss of tension and changes associated with the aging of the supports; however, in the short term, the treatments show clear efficacy in correcting deformations without returning to the deformed state. Despite the uncertainties and the lack of research on the use of magnetic systems in conservation and restoration in general and in the correction of support deformations in particular, the advantages of the treatments with magnetic sheets are clear and their use is encouraged in a critical and analytical way, proving to be a useful method and tool for the treatments described or for other equally possible ones, such as the consolidation and fixation of layers or supports, treatments of paper supports, etc.

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Notes

[1] Methodology applied to the treatment of a vandalised 19th century painting. The painting had a series of tears in the centre of the work, and the support was planned using magnetic plates without the need to remove the painting from the frame. The information can be found in the master's thesis entitled "A tomada de decisão perante um ato de vandalismo: confronto entre os valores históricos e estéticos na intervenção de conservação-restauro do retrato de D. Maria Ermelinda Vianna" by the student Beatriz Helena Marques Pinto, School of Arts, Universidade Católica Portuguesa, 2023.

[2] Information collected from the "magnetpt" website (https://www.magnetpt.pt/) where one of the magnetic sheets used in this study was purchased.

[3] Information collected from the "imamagnets" website (https://imamagnets.com/pt-pt/imas-flexiveis/), where one of the magnetic sheets used in this study was purchased.

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