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title: Magnetic Systems as an Alternative to Traditional Methods for the Conservation-Restoration of Painted Canvas Supports

subtitle: A Proposal of Minimal Intervention Protocols

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abstract: This research shows the application of neodymium magnets in the conservation/restoration of paint on canvas, establishing minimal intervention as the main criterion. In an innovative way and with the aim of respecting the authenticity of the original, a new tool has been designed consisting of an internal auxiliary frame equipped with a magnetic system (IAFMS). Its use contributes to facilitating and improving the operation during some procedures, such as thread-by-thread sutures, textile intarsia, and thread bridges reinforcement.

short\_title: Magnetic Systems as an Alternative to Traditional Methods

# <A-head> Background

During the last decades, the criterion of minimal intervention has acquired great importance and continues to guide the actions of conservative practitioners aiming to keep open options for retreatment ({{Appelbaum 1987}}). In the specific field of painted canvas supports, progress has been constant as a result of the search for new operational methodologies that continue to provide better responses to the problem of deterioration. Neodymium magnets have a wide field of application in the assembly of objects in permanent and temporary exhibitions, especially graphic works, textiles, and decorative arts collections ({{Spicer 2019}}), but specific applications for pictorial works are still scarce ({{Bestetti 2005}}; {{Rella and Saccani 2006|, 17–19}}; {{Sterp Moga and Sánchez Ortiz 2019}}) .

An internal auxiliary frame equipped with a magnetic system (IAFMS) has been developed by the authors to assist the conservator in maintaining tension during conservation procedures involving thread-by-thread suture for tear mending, textile intarsia, and reinforcement with thread bridges. The frame is equipped with a magnetic system on the inner and outer edges, consisting of different magnets embedded flush with each edge and a U-shaped iron gutter, adequately protected ([**fig. 59.1**](fig-59-1)). The magnets holding the gutter allow the gutter to be raised and lowered to bring the threads closer to the surface of the damaged canvas. Different magnets are housed in the gutter; these act as a clamp and allow the textile material (the necessary threads with the warp and weft) to be held according to the needs of the tear, gap, or break in the textile support. In addition, the system allows the application of a minimum tension by means of the tensioners composed of stainless-steel dowels and threaded rods and nuts placed in the four corners of the frame. In short, the IAFMS allows the tension of the threads to be maintained and exactly positioned during treatment, thus facilitating the adhesion of the suture. At the end of the procedure, the frame and the excess threads are removed from the treated area.

<A-head> **Materials and Methods**

# <B-head> *Tension Value Studies*

The continuous environmental changes to which paintings on canvas are subjected are one of the main agents of deterioration, as the constituent materials respond in very different ways. As a result of mechanical stress and the release of this stress, the canvas becomes loose and deformed, with the consequent appearance of folds and other deformations.

In 1950, Roberto Carità carried out the first studies on the quantification of the mechanical tension forces and made the first prototype of a frame with springs ({{Carità 1955}}). Gustav Berger and William Russell carried out experimental tests showing that canvases are capable of withstanding a maximum tension of 100 N/m when exposed to environmental conditions of 21°C and 60% RH ({{Berger and Russell 2000}}).

In more recent research, Antonio Iaccarino has analyzed what could be the most suitable tension parameters for paintings on canvas mounted on frames modified with a spring system. According to the results, the tensions should be between 1.5 N/cm to 2.6 N/cm, with some cases being acceptable up to 3.4 N/cm ({{Iaccarino 2009}}).

## <B-head> *Thread Tension Tests*

Different threads were selected for testing, both synthetic and natural: Lipari, 260 g/m²; Ispra, 130 g/m²; cotton, 320 g/m²; and linen 2297, 170 g/m². A selection of block-shape neodymium magnets with a protective nickel coating (NiCuNi) were also tested, of varying dimensions and grades (magnetization): 8 x 8 x 4 mm (N45), 10 x 10 x 3 mm (N42), 25 x 6 x 2 mm (45SH), and 20 x 10 x 2 mm (N45). Each thread was stretched between two magnets by means of a high-quality digital balance for forty-eight hours.

## <B-head> *Elaboration of the Models*

Three samples of each of four types of models were made: (A) Lipari synthetic fabric, ) 260 g/m², and a preparation of Talens acrylic gesso; (B) Lipari synthetic fabric, 130 g/m², and a preparation of plaster (calcium sulfate) and rabbit-skin glue; (C) cotton fabric, 320 g/m², and a preparation of plaster, chalk, and PVA latex; and (D) linen 2297, 170 g/m², and industrial preparation with vinyl resin (Modostuc). Different damages were inflicted on the samples. They were subjected to different cycles of artificial aging by means of ultraviolet radiation by means of 16 Ultra Vitalux lamps (300 W/230 V), at a temperature of 50⁰C and a relative humidity of 20%–25%, for 700 hours. The aging protocol followed the ISO 4892-2 standard.

## <B-head> *Tension Measurement*

The tears caused by artificial aging were treated using two methods: first without tensioning the new threads and then by subjecting them to slight tension using the IAFMS tool. Measurements were taken before and after the operation to see which method was more effective using a HT-6510N tension meter. The models were also subjected to relative humidity oscillations between 50% and 80%.

## <B-head> *Creation of the Frame and Selection of the Magnets*

The IAFMS measures 25 x 25 x 2 cm and is made of laminated spruce. The four corners of the frame are cut at 45 degrees and consist of a tensioning mechanism composed of stainless-steel pins, threaded rods, and nuts.

To carry out the local treatments on the support-thread by thread suture, textile intarsia, and thread bridges reinforcement-IAFMS has a magnetic system located on the edges of the slats. It is composed of an iron chute with an anti-rust coating and has three magnets on the outer edges and two on the inner edges. The system acts as a clamp holding the warp and weft threads according to the needs of the damage to be treated (see [**fig. 59.1**](fig-59-1)). The new threads are held to the mechanism with the different axial magnets mentioned above.

## <B-head> *Textile Microsurgery*

Yarns extracted from the textile used for each model were used (. They were laid by both the traditional method and by IAFMS ([**fig. 59.2**](fig-59-2)). The adhesive selected for the sutures and the textile intarsia was 10% starch paste at and 20% sturgeon glue; a small drop was deposited with a brush on each thread to be sutured. In the case of the reinforcement bridges, the threads were impregnated with Plextol B500. Each new thread was aligned and placed in its exact position and then kept taut at a value of 1 N/cm as the adhesive was reactivated with a thermal spatula.

# <A-head> Results and Discussion

## <B-head> *Measurement of Wire Tension and Tension of Painting Canvas*

The results obtained are shown in [**table 59.1**](table-59-1). The N45 magnets measuring 20 x 10 x 2 mm () were selected for their dimensional characteristics, which better adapt to the magnetic system of the frame. These magnets have approximately 20.6 N in direct contact with each other, and when used to tension the thread they produce a maximum tension of 2.64 N. As shown in [**table 59.2**](table-59-2), after the intervention with the neodymium magnets on the models a tension of between 2.8 and 3.5 N/cm was achieved. This tension was kept constant practically after 24 hours of having been subjected to RH oscillations. Therefore, this is an adequate tension for the desired conditions during conservation of paintings.

## <B-head> *Thread-by-Thread Suture*

When the traditional thread-mending method was used, the tension values remained between 0.1 and 0.3 N/cm. After the model was subjected to fluctuations in relative humidity, the treated area experienced a general detensioning. The tension applied to the new yarns with IAFMS allowed us to achieved better results while providing adequate tension (2.5–3.5 N/cm) in the area of the treated textile support. During the relative humidity oscillation tests, the tension values were maintained in this range, so the intervention was considered adequate for the intended purpose.

## <B-head> *Textile Intarsia*

With nontensioned thread, tension values are between 0.3 and 0.5 N/cm. When the models were subjected to fluctuations in relative humidity, the area being worked on relaxed. If during the process of laying the thread they are held in place at a tension of 1 N/cm, the treated area has a tension of 2.5–3.5 N/cm, and the whole remains stable.

## <B-head> *Thread-Bridge Reinforcements*

Without adding tension, the treatment carried out with the new threads did not achieve good results. The model showed a tension of 0.5–0.8 N/cm—a value insufficient to guarantee the stability of the textile support. When using IAFMS, the yarns are kept at a tension of 1.5 N and the tension is 2.8–3.4 N/cm. These values remained stable.

# <A-head> Real-World Applications

Two anonymous works were chosen to test the IAFMS tool in practice. Both works showed a generalized weakening of the fibers of the support due to oxidation and to the existence of various tears in the fabric as a result of adverse exposure and storage conditions.

## <B-head> *Case Study 1*

The first painting was an eighteenth-century representation of the Virgin and Child rendered in oil on linen, measuring 104 x 76 cm. The textile support has a plain weave and a traditional preparation of plaster and glue.

The adhesive was chosen for suturing thread by thread: 10% starch paste and 20% sturgeon glue in water (1:1). Natural linen threads 2297, 170 g/m², were used and maintained at a tension of 1 N/cm thanks to the IAFMS ([**fig. 59.3**](fig-59-3)). At the end of the operation, the textile support showed a tension of 3.2 N/cm in the treated area. For the reinforcement bridges, the same natural linen threads were used, but impregnated with Plextol B500. The tension applied with Q-20-10-02-N magnets and IAFMS was 1.5 N. Once the treatment was finished, the treated area maintained a tension value of 3.0 N/cm.

## <B-head> *Case Study 2*

The second work was an oil painting on cotton cloth, dating from the twentieth century, whose motif is a still life. It is supported with a taffeta ligament, is industrially prepared, and measures 98 × 48.5 cm.

Cotton fabric threads, 320 g/m² ([**fig. 59.4**](fig-59-4)) were used, along with and 10% starch paste and 20% sturgeon glue in water (1:1) as adhesive for the textile intarsia. Because a water-based adhesive was used, small dots were applied to the ends of each thread. The tension of the new threads was 1 N/cm, and after the operation was completed, the treated area had a tension of 3.5 N/cm.

# <A-head> Conclusions

Experimental tests demonstrate the validity of using neodymium magnets as an alternative to traditional procedures in the conservation of painted fabric supports. The magnetic IAFMS allows one to make treatments of sutures thread by thread or using textile intarsia, or thread-bridge reinforcement, minimizing the manipulation of the work and with it the risks. 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.