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TEXTILE CONSERVATION

PAST, PRESENT AND FUTURE

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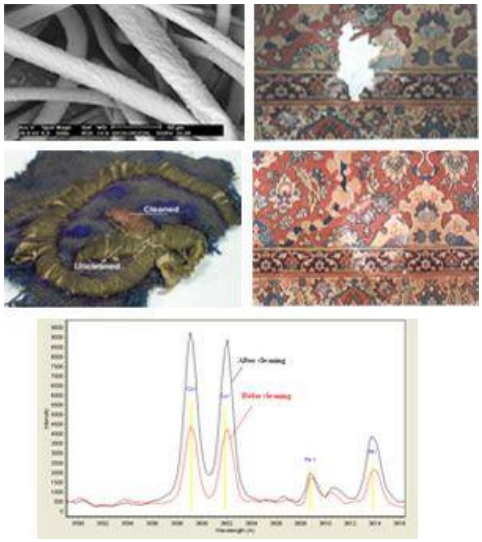
HIGHLIGHTS

- Nowadays there are multiple developments in textile conservation because of the advancements in most branches of sciences such as chemistry, biology, physics, humanities, historian, and applied arts. But still there is a necessity to do more researches in this field.
- This paper introduces a review and some practical experiences in textile conservation field and presents new suggestions on the future of textile conservation in Egypt.
- Suggested future works to explore non-invasive techniques for investigation and conservation of textile artifacts, were recommended.

GRAPHICAL ABSTRACT



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ABSTRACT

It is probably that textile conservation has been carried out for nearly as long as textiles have been used by man. Nevertheless, there is no doubt that textile conservation in the past was far from the basic scientific rules that are common and known today. Textile conservation science is a multidisciplinary science which includes various branches of sciences such as chemistry, biology, physics, humanities, historian, applied arts, etc. To succeed in conservation of textile artifacts, it is necessary to follow the advances in all of these branches. Nowadays, there are advanced developments in all of these sciences. The most common conservation processes of a textile object include cleaning, stabilization, restoration, exhibition and storage.

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This paper aims to introduce several practical experiences in textile conservation field and present new suggestions on the future of textile conservation in Egypt. It may raise awareness and promote further opportunities for the collaboration of all scientists from all branches of sciences and make use of all developments in textile conservation field. This study recommended future works on exploring non-invasive techniques for the investigation and conservation of textile artifacts.

1. Introduction

The extent of historical textiles provide rich evidence of social history, international trade, agricultural development, artistic trends and technological developments. For this reason, every effort should be done to preserve these textiles and to pass them on to the next generation. The aim of any conservation processes carried out on textile objects is to enhance the long-term stability of these textiles against deterioration factors while on display or in storage [1]. There is no doubt that textile conservation has started from a long time for nearly as long as textiles have been used by man but was far from the basic scientific rules that are common and known today. In the past, there was no rules and ethics for textile conservation. The textile objects were repaired by stitching methods without any rules to follow. Furthermore, the textile objects were cleaned in a way similar to household washing. Most of textile conservation included restoration processes, such as stitching and fixing any deteriorated and splatted area in the textile's objects. Sometimes patches can be used in repair work [2]. Nowadays, there are thousands of papers related to textile conservation and many text books that are very important for those interested in textile conservation [2-18]. Textile conservation science is a multidisciplinary science which includes various branches of sciences such as chemistry, biology, physics, humanities, historian, applied arts, etc. To succeed in conservation of ancient textiles, it is necessary to follow all developments in these branches of sciences and make use of all these development in textile conservation field. Nowadays, there are advanced developments in all of these sciences. The most common conservation processes for textile objects include cleaning, stabilization, restoration, exhibition and storage. Any conservation process should begin with a complete examination and documentation of the object [8]. Identification of the nature of the materials that constitute a textile object is an essential preliminary step for establishing an effective conservation treatment; and if possible, it should be carried out with non-destructive methods [19]. The decision of selecting any conservation process for historical textile objects should be based on a compromise between preservation of evidence and enhancement of the long-term preservation of the constituent materials of the object. [2, 5]. We have to compare effective treatment such as soil removal against the possible damage that might be caused by cleaning [20, 21, 6, 22, 23]. This paper aims to introduce a review of some significant points in conservation of historical textiles. It further gives a highlight on some practical experiences in textile conservation field and presents the opinion of the author on the future of textile conservation in Egypt. It is not intended to be a technical article; but hopefully it may raise awareness and promote further opportunities for the collaboration of all scientists from all branches of sciences and make use of all developments in textile conservation field.

2. Investigation methods

Material investigation is a necessary step in the documentation of the properties of the component materials of a textile object [2]. Identifying the component materials of a textile object can help historians and archaeologists in solving, interpreting and replying to many of strange questions [8]. Investigation of materials is a necessary task for estimating the condition of a textile object, establishing an appropriate conservation treatment, and for following up the result of the application of any suggested treatments. Moreover, material investigation plays a fundamental role in selecting materials and methods that can

be used in display or storage of this object. The efficiency of a method which can be used for investigating a historical textile object should be evaluated and chosen according to its diagnostic power, representative nature, reproducibility, destructiveness/invasiveness and accessibility [24]. Not all methods and techniques conventionally used in textile technology are useful for investigating the chemical and physical properties of ancient textiles [25]. However, there are many efforts and articles that have published on the investigation of textile materials that can help conservators in this point [8, 26]. Transmitted light microscope and scanning electron microscope (SEM) have been reported for identifying fibers and for understanding the deterioration of the textile materials. SEM with EDX has been used in the detection of metallic mordant [27]. Although there are a lot of methods and techniques that are known and used in the investigation and identification of textile materials, there are many precautions and challenges such as the effect of ageing on the physical and chemical properties of these materials (Fig. 1).

Investigation of dyes is a very important task in order to choose the proper methods for cleaning a textile object and for choosing the proper colors to be used in its restoration [8]. The detection and identification of colorants present in textiles of archaeological or historical importance sheds unprecedented light on social, cultural and economic status of a particular period or geographical area, its trade connections, and technological capabilities of its population. The unambiguous characterization of dyes is of immense value to historians, archaeologists and conservators addressing questions on the provenance, authentication and restoration of our irreplaceable textile heritage, with the data from dye analysis being important for factual documentation, deterioration assessment and rational choice of conservation treatments and restoration of historical artefacts. The chemical characterization of dyes in heritage textile objects is also relevant to preventive conservation strategies and long-term preservation as many organic colorants are not stable to light over long periods of exposure [28]. The most common techniques which have been used for the analysis of ancient dyes are wet chemical analysis, infrared (IR) spectroscopy, thin-layer chromatography (TLC), ultraviolet/visible (UV/Vis), three-dimensional fluorescence spectrum and high-performance liquid chromatography (HPLC)-28 ،26 ،24] .[36

It has been reported that HPLC is one of the most common and useful tools that can be used to investigate ancient dyes on the textiles [37-38]. A study that has been done on wool dyed with weld and sawwort showed that after exposure to approximately 10000 lux of simulated daylight through glass for 4500 hours (i.e. equivalent, very approximately, to 60 years exposure at 250 lux for eight hours each day), the two distinguishing flavonols (i.e. quercetin and kaempferol) degraded, leaving the HPLC-PDA dye profile of sawwort looking very similar to that of weld (Fig. 2) [39]. Finally, it can be concluded that there is a necessity to develop novel investigation methods that can overcome the drawbacks of current methods. Furthermore, there is a necessity to explore non-invasive techniques for the diagnosis and detection of deterioration on textile artefacts which can be easily used by conservators.

The use of scanning electron microscopy (SEM) along with energy dispersive X-ray spectrometry (EDS) is considered to be suitable for the identification of metallic mordants on textile fibers. Most of SEM-EDS applications (except Variable Pressure SEM) require the samples to be either conductive or coated in gold, graphite or any other conductive material. Moreover, energy dispersive fluorescence (ED-XRF) is a common elemental technique for the mapping of metallic mordants on textile fibers. However, both techniques are limited by low sensitivity (i.e. XRF is unsuitable for the analysis of light elements such as aluminum). Nowdays, surface-enhanced laser-induced breakdown spectroscopy is used for the identification of inorganic dyeing mordant in textiles (Fig. 3) [30].

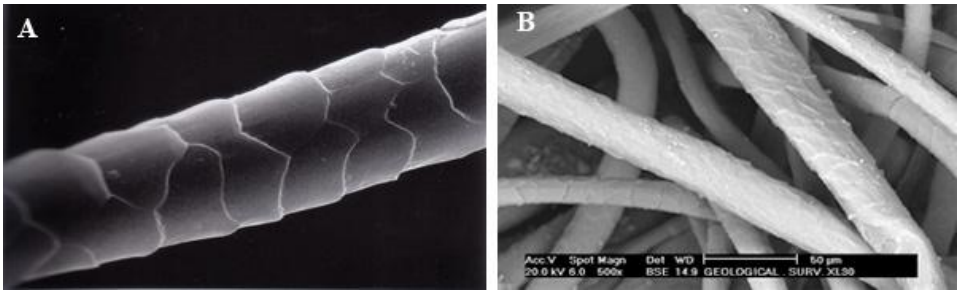

Fig. 1: Apparent differences between the surface features of an ancient wool sample and a new one investigated by SEM. A) New wool fiber characterized by the presence of many scales on the surface, B) Ancient wool fiber characterized by abrasion and losses of the scale structure.

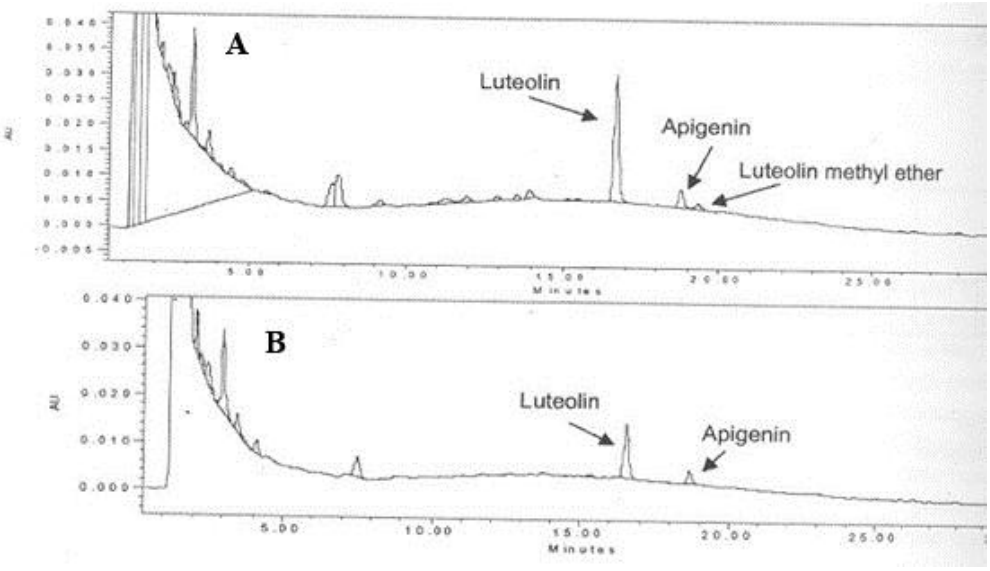

Fig. 2: Comparative HPLC-PDA dye profiles for A) Sawwort after exposure to accelerated light ageing conditions and B) Weld [39].

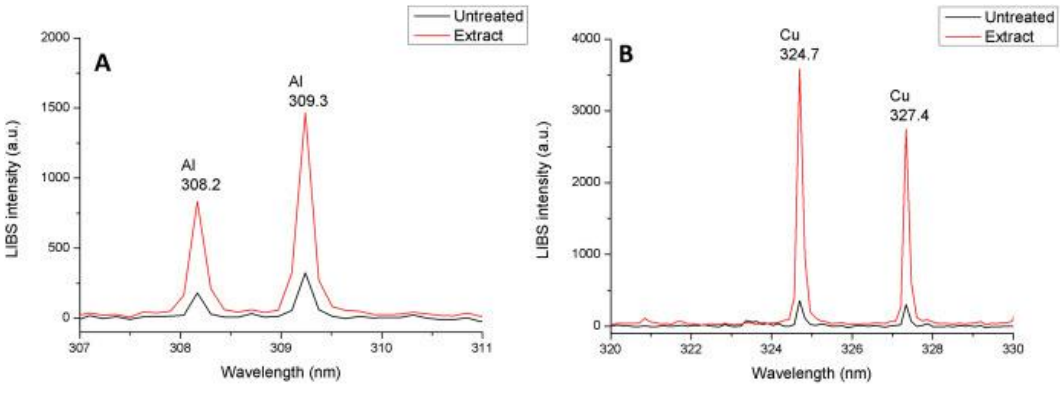

Fig. 3: Insets of LIBS spectra relative to each inorganic mordant of cochineal dyed silk (A, Al), European buckthorn dyed wool (B, copper), and oak gall dyed wool [30].

3. Conservation Processes

3.1.Cleaning Methods

Cleaning is usually the first step and the most difficult to be implemented. Cleaning processes used in the cleaning of museum textiles should be carried out with great respect and consideration of the original object's form, function and material. Traditionally, conservation treatment usually starts with vacuum cleaning the object to remove dust. Some textiles are also wet cleaned with a detergent. There are two ways of washing textiles. Both of them employ a system of alternating soaking and rinsing but the first employs a flow of water across a flat, sloping surface for rinsing while the second involves successive changes of a depth of water contained in a tank or tray [10]. Among the previous two wet cleaning methods it was reported that cleaning using impregnation method is the most appropriate method for cleaning archaeological textiles [7, 8].

Whatever method is used, any weaknesses in the object must be supported in some way throughout the process; strain, arising from being moved without support, must be avoided, as weakened fibres are more easily damaged when wet (Fig. 4a). However suction table is the most popular tool that is very useful for cleaning of ancient textiles either with wet cleaning or solvent cleaning. It also can be used in stain removal. However, there are many problems in washing ancient textiles. There is a variety of archaeological and historical textiles that require individual treatments, such as fragile textiles, or textiles with fugitive dyes and so on. Also, sometimes in archaeological excavation sites the facilities for treatment are limited. The supply of deionised water may be limited and the special surface-active agents might be difficult to obtain. Adjusting detergent formulations may help to address some of these special conditions. The formulations of a universal detergent, which can be used under the most undesirable circumstances, were attempted and also separate formulations for particular circumstances.

For cleaning a Coptic tunic as a case study, the following processes have been used. After profound investigations, it was found that the tunic suffered from too much stains and dirt distributed all over, and fiber damage and collapse which could not tolerate any mechanical vibrations. Accordingly, wet cleaning, particularly immersion, was considered to be the best choice due to its ability for removing many types of dirt and stains, thus its potential to soften and relax the fibers which results in reducing creases and also improving the chemical properties of the tunic. The detergent used in cleaning the tunic was: Orvus WA (Sodium dodecyl sulfate) from FLUKA. Orvus WA detergent is recommended for cleaning dirty textiles due to its properties, excellent washing power, and good foaming property. Moreover, it is also working well in hard water [2]. The prepared washing components were dissolved in deionized water. Since the available facilities and equipments in the conservation Lab in Coptic Museum are too limit, the cleaning process was not carried out on a suction table. Alternatively, a simple and cheap tank from available materials was prepared. Hence, timber boards and polyethylene sheets are the only basic materials for washing tank creation. This technique proved to be an effective, good and easy technique for cleaning ancient textiles in developed countries such as Egypt since there is no fund enough to buy washing tables for cleaning archaeological textiles. Prior the cleaning step, it was imperative to experiment the effect of this washing solution on studied object to ensure its effectiveness without any side effect. Consequently, the solution was applied on a small spot before whole immersion of the object. In addition, testing for dye sensitivity was carried out to ensure object safety for further cleaning application. In this test, a small corner of the object was placed between two inert white cotton and wool fabrics with some drops of water and slight pressure was applied by hand to detect any fabric discoloration or dye bleeding.

Fortunately, no discoloration was observed and thus the solution was safe for our object to go forward to the next steps. The cleaning shallow tank was made from four timber boards large enough to suit the object dimensions and attached in a rectangular shape then covered with heavy – duty polyethylene

sheet to form the tank base. The washing tank was filled with the prepared washing solution so that it is 5cm over the object. Then, the supported object was carefully inserted into the bath and was allowed it to become properly saturated and was immersed for about (20 – 30) min. This time proved to be the ideal duration to prevent too much swelling or hydrolysis of the degraded fibers [22, 23]. To assist the distribution of washing solution inside the tank, the water was gently agitated with hand palms, (Fig. 4b) until there were signs of movement of dirt and discoloration. After the first soaking bath, the author noticed the loosening of tough stains and the removal of slight ones. The object was removed from the tank. Then, the unclean water was drained away. This washing process was repeated again with deionized distilled water for 3 to 4 times until the water seemed clear and all signs of detergent has disappeared. This important step ensured that there is no residual detergent present inside the fibers which may cause further damage. By observing the obtained washing solutions, it is clear that too much dirt and soils were removed from the object (Fig. 4c), and there is an obvious improvement in the surface of textile object after cleaning process.

Conservation of historical objects made from composite materials is a complex operation, since conservation materials that may suite the treatment of one component may be harmful for the other [19, 25]. For instance, cleaning agents which are effective for cleaning metals may cause harm to core yarns, ground fabric or to needlework pads. Therefore, it is essential to find a common conservation approach and materials that respect the integrity of the object to be treated and can preserve all components. In recent years, new methods for cleaning composite textiles have been developed especially for those encountered special cases such as metal threads. Nowadays, laser cleaning is increasingly becoming popular for cleaning such complex objects [40 - 42]. Laser cleaning is an effective cleaning technique of metal threads on textile artefacts since it provides a high degree of control that allows fragile objects especially those with a considerable amount of surface detail to be effectively and safely cleaned [22, 41]. Laser can be used in cleaning and analysis of metal threads [21]. Laser was investigated for cleaning of ancient copper-metal threads and gave good results (Fig. 5). Also, LIBS was used to analyze metal threads and control the cleaning process applied on these threads (Fig. 6). Finally, more research should be done to explore new techniques for cleaning fragile textiles especially those composed of various materials such as textile decorated with metal threads.

3.2. Reinforcement of textiles

The fragility of deteriorated textiles causes some conservation problems. For this purpose, conservators have used polymers in an attempt enhance the long-term preservation of these types of textiles. After using polymers in textile conservation, conservators were divided to 2 teams, one team accepted the use of polymers while the other team refused. In fact, when polymers were first used in textile conservation, it encountered many problems such as using inappropriate polymers and using inappropriate processes for the application of these polymers. For example, using starch, Arabic gum, polyvinyl chloride, etc caused a lot of problems to the conserved textiles. However, there is no fear in using polymers even with these previous attempts since polymers may enhance or reduce the durability of conserved textiles according to nature of the used polymer and the process used in its application (Fig. 7).

Today, a wide variety of polymers have been evaluated and conventionally used in textile conservation. Polymers can be used as consolidating materials or adhesives in the conservation of deteriorated textiles [2, 9, 10, 43 - 51]. Also, there are many researches about developing polymers to be used in textile conservation [46, 48, 52]. There are various methods that can be used in the reinforcement of fragile textiles with polymers. Abdel-Kareem et al. [9], confirmed that reacti vation consolidation technique is simple and effective for the reinforcement of ancient Egyptian linen objects (Fig. 8).

Fig. 4: Shows the cleaning process used in wet cleaning of fragile and damaged Coptic textile object, a) reinforcement of the tunic before wet cleaning, b) soaking and cleaning of the tunic in special tank designed and prepared for this step, c) washing solutions before, while and after the end of cleaning and rinsing the textile object.

Fig. 5: An optical microscopy image shows the surface appearance of the metal threads after laser cleaning [21].

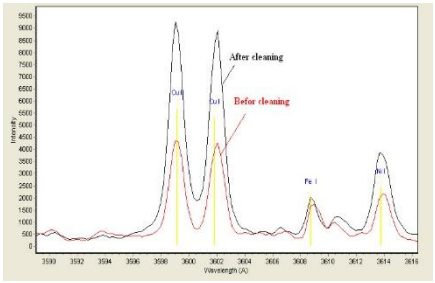

Fig. 6: LIBS spectra before and after laser cleaning of the metal thread. The red curve before cleaning, and the black curve after cleaning [21].

Fig. 7: The effect of a variety of tested polymers on linen textile after ageing by light for 200 hours, some of these polymers reduced the deterioration of the textile while others caused the textile to become stiffer and dry with browned colors.

Fig. 8: Shows the conservation of ancient Egyptian linen shroud from the Egyptian Museum in Cairo with polymers with reactivation consolidation technique, A) before treatment, B) after conservation [9].

The obtained reactivation technique can be easily applied by using simple tools that are commonly present in conservation laboratories. Silk screen and Lascaux 498 are suggested to be used with this technique.
According to the aim of the conservation, polymeric material should be characterized by physicochemical properties suitable for binding damaged fibers and yarns, imparting physical strength to the artifact, or improving the adhesion between the artifact and a support fabric. The ideal properties should be flexibility, transparency, adhesion and cohesion, lack of color, long-term durability, reversibility, possibility of reactivation for adhesives, ease and rapid application with no risks for the operators [43, 53, 54]. However, there is no existent polymer that encounters all of the previous properties. Accordingly, in the future, scientists should search to produce polymers more suitable for textile conservation and that encounter all previous properties. Further investigation should be done to investigate the long-term stability of textiles treated with any suggested polymers. Also, more research should be done to develop new methods for the application of polymers in textile conservation.

3.3. Restoration

Restoration of a textile object aims to recreate the visual and physical appearance of the object as it is originally believed to have looked. This also raises the interesting question of the distinction between a restored object and a fake. This depends on the actual treatment carried out, or on the way in which the treated piece is presented to the public [55]. For compensation, there are different methods had been used to compensate the loss areas [56 - 60]. However, Green, and Swetzoff [61], summarized these methods to six repair techniques. 1- Reknotting with the insertion of a partial or complete new foundation. 2- Emberoidery techniques. 3- Inserting a carpet patch cut from another carpet. 4- Patching with fabric attached from the back using needles and threads. 5- Patching with fabric or with patch cut from another carpet using adhesive. 6- A complete lining attached to the back of a carpet with couching stitches used to stabilize loose elements either to patches or to the lining itself (i.e. technique similar to traditional tapestry repair). Abdel-kareem, explored a new restoration technique for carpets involving the replacement of missing areas using previously prepared pieces identical to the original but made by a different technique and fixed by stitching. This method is reversible and in agreement with conservation ethics (Fig. 9-14) [55].

The technique used by Abdel-Kareem involves the following: Preparation of new pieces identical to the original:

1-Identify the exact area of any loose part by placing a sheet of very thin transparent ramie fabric (i.e. pure cellulose) behind any areas in need of compensation. Then, from the front, draw the outline of the hole, marking the correct size of the require new piece. 2- Recreate and design the decoration on the previous identified area to resemble the original pattern. This step was simple since the patterns were copied from another place with similar patterns. Anyhow, the patterns of most carpets are governed by rules of symmetry [58]. 3- Fix a cleaned undyed cotton fabric in place on the artist's wooden frame. 4- Fix the prepared transparent ramie fabric with designing decoration on the cotton fabric up on artist's wooden frame. 5- Dye the threads of natural wool (i.e. 100% wool, and in appropriate thickness) with fastness dyes in various color similar to original ones). 6- The decoration was done using needles and wool threads with appropriate colors, the procedure was repeated until accumulating the adequate aesthetic appropriate surface, similar to the original one but in a way different than the fake, as the piles are not knots, only plug accumulating threads. 7- Fix the stitches using dyed cotton threads and needles were used to secure and fix the new developed piles with the backing. 8- The completed prepared new compensation part with the correct size, was carefully cut out the wooden frame with pinking shears.
Attaching the new pieces to the carpet: 1- Mounting and patching each hole with appropriate linen packing. This packing was attached to the carpet diverse by stitching with needles and threads.

Fig. 9: The missing part before restoration

Fig. 10: Designing a piece that is identical to the original one

Fig. 11: Preparing a new piece that is identical to the original

Fig. 12: The new piece

Fig. 13: Stitching the new piece in place

Fig. 14: The previous missing part after restoration

2- The edges of the hole was fixed with the patches using herringbone stitches. 3-The damaged warps ends and wefts of the carpet around the hole were left in place and secured on the backing linen fabric. 4- Each new compensation part prepared previously was stitched directly into the appropriate hole of the carpet with the backing linen fabric that was stitched previously to the carpet. The author concluded that this developed technique is quite successful. 4- It provides an adequate aesthetic compensation for losses in oriental carpets since the public viewers and visitors can not easily distinguish between the original knots and the new fill. 5- It also appears to respect the fundamental principles of restoration. 6- It recreates the visual and physical appearance of the carpet as it is originally believed to have looked; however, one can still differentiate between the original and the restored area. 7- This technique respects the outset of the carpet: visual and aesthetic continuity, original materials, structural soundness, and reversibility. 8- This technique allows for minimum handling of the object as it can be done on wooden frame out of the carpet and then stitched directly into the lining fabric that stitched previously with the carpet.

4. Conclusion

The study concludes that nowadays there are advanced developments in textile conservation as a result of the developments in all branches of sciences such as chemistry, biology, physics, humanities, historian and applied arts. Yet, there is a necessity to do more researches in textile conservation science to achieve the following developments. Exploring non-invasive techniques for diagnostic and detection of deterioration on textile artefacts by conservators such as using Laser Induced Fluorescence (LIF) technique for identifying dyes [62], fungi and stains on textiles. Exploring new techniques for cleaning fragile textiles especially those composed of various materials such as textile decorated with metal threads. Exploring new materials which can be used safely in textile conservation such as producing new polymers with all ideal properties required for polymers suggested for use in textile conservation. Exploring new methods which can be used safely in storage and display of textile artifacts in museums, such as producing an environmental condition similar to that used in ancient Egyptian tombs which contributed in the preservation of the textile objects in these tombs until they were discovered.

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