THE MICROSCOPE Vol 57:1 pp 3-9 (2009)

Microscopical Identification of 19th Century Corset Cording Fibers

Kelly M. Brinsko
McCrone Research Institute*

KEYWORDS

Hair degradation, hair identification, human remains, skeleton, cording, binder, historic textiles, fiber identification, fabric, clothing, polarized light microscopy (PLM), stereomicroscopy, transmission electron microscopy (TEM), scale casts, chloroform, Norland Optical Adhesive (NOA)

ABSTRACT

An intact and relatively well-preserved length of cording dating from ca. 1854 was obtained by the author for fiber identification. The cording had been found inside a cast iron casket with human skeletal remains and clothing material. Based on the distribution and arrangement of the multiple cording pieces found within the coffin, they are believed to have formed the stiff boning of a corset. Microscopical analysis revealed the cording to be made up entirely of mammalian hair, which had degraded to a point that made species determination impossible. However, the widths of the hairs (150-250 μm) indicate nonhuman origin. Despite the severe degradation, no evidence of fungal activity was seen, which is likely due to the favorable conditions within a well-sealed iron coffin.

INTRODUCTION

A cast iron coffin was recently unearthed from a cemetery in Lexington, Missouri, for anthropological investigation. Human skeletal remains, along with several items of clothing, were found within the casket. Historical records indicate that the remains are of a 22-year-old woman buried in 1854. Skeletal abnormalities of the ribs and vertebrae suggest that the individual wore tightly laced clothing, and specifically corsets, in her lifetime. This corresponds well with the clothing fashions popular during that time period. Typically, corsets of this era were made of cotton, with baleen (whalebone), cork, steel, coralline (reed grass), or feather quills used to form the stiff boning material (1).

Underneath the thorax region of the skeleton in the casket, and attached to clothing material, six pieces of cording were found. The arrangement of the cording pieces corresponds to the placement of cords stitched into a corset (1). One of these six pieces of cording was sent to the author for fiber identification (Figure 1). Stereomicroscopy and polarized light microscopy were employed for the analysis.

MATERIALS AND METHODS

Polarized Light Microscopy

Fibers that were already loosened or separated from the intact cording were cut away using a Teflon®-coated razor blade. The fiber was then mounted on a glass microscope slide using temporary mounting media: Cargille Refractive Index Liquids (R.P. Cargille Laboratories, Inc), n=1.662 initially, then n=1.520 for later analyses. The mount was coverslipped and examined using an Olympus BH-2 transmitted polarized light microscope (PLM) and a Nikon Optiphot transmitted polarized light microscope. Both PLMs

* 2820 S. Michigan Avenue, Chicago, IL 60616

Figure 1. Stereomicrographs showing three different views of the same sample of corset cording (and other particulates).

were equipped with a rotatable analyzer and first order red (530 nm) compensator. Total magnification ranged from 100x-1000x. Photographs and measurements were taken using the Olympus DP-70 digital camera with DP Controller software, or alternatively, a Nikon Coolpix 995 digital camera.

Transverse cross-sections (individual fibers)

Cross-sections were made across the width of several individual fibers from the cording. Fibers that were already loosened or separated from the intact cording were cut away using a Teflon®-coated razor blade. The single fiber was placed on a glass microscope slide and held steady with a fingertip while a Teflon®-coated razor blade was used to slice very thin segments of the fiber. Precise, practiced strokes produced cross-sections that were thin enough for PLM observations. Cross-sections were mounted on a glass slide first dry, then later in Cargille Refractive Index Liquids for observations.

Transverse cross-sections (whole cording)

In order to preserve the arrangement of the hairs making up the cording, Norland Optical Adhesive (NOA) #65, n=1.524, was used to embed a small part of the whole cording. A 2 x 3 mm section of the cording was cut using a Teflon®-coated razor blade. Several layers of NOA, which cures under long wave UV light (350-400 nm), were placed over the cording section on a clean glass slide until it was completely enveloped. The NOA was cured after each new layer addition for approximately 15 minutes using a hand-held UV light source. Once the medium was satisfactorily cured and the cording was entirely embedded, a Teflon®-coated razor blade was used in hand-sectioning the entire cording piece in the same manner as described for individual fibers, above. Observations were made using both the stereomicroscope and PLM.

Scale casts

Scale casts were performed on several individual hairs as follows: a thin layer of clear nail enamel was painted on a clean glass slide and allowed to partially set for approximately 30 seconds. A fiber was then gently placed on the nail enamel until the enamel hardened. Once hard, the fiber was pulled up from the nail enamel. If scales are present, their imprint will remain in the nail enamel and can be viewed using transmitted light microscopy.

Test for the presence of binder

In order to determine if any binder was present in the cording, a small piece of cording (approximately 10 x 3 mm) was placed in a Pyrex® test tube and immersed in approximately 1 mL of room temperature chloroform. If present, chloroform will extract most organic binders into solution, and the cording would be expected to break up. Gentle heat was also applied in case the binder was particularly stubborn (2). The chloroform supernatant was then spotted onto a KBr salt plate for transmitted FTIR microspectoscopy, using a Mattson Galaxy 5020 equipped with a Quantμm Infrared Microscope. Any spectra obtained were searched against an extensive IR library.

RESULTS

The cording dimensions measure approximately 105 mm long, 7 mm wide, and 1 mm thick. The gross morphology of the cording is generally flattened and

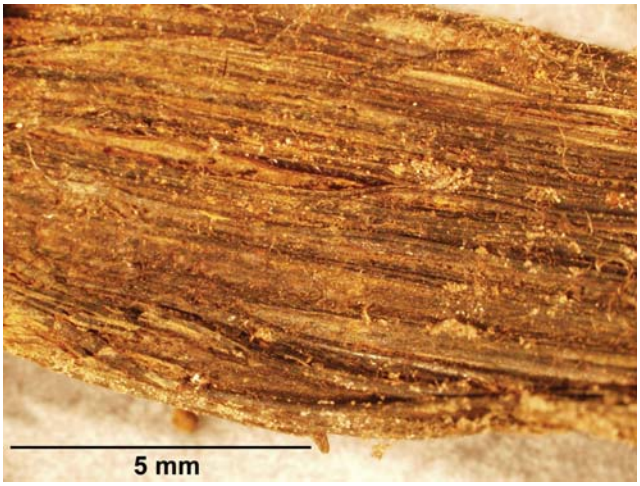

Figure 2. Close-up view of the "textured" side of the cording. Note that individual fibers can be seen running parallel to the length of the cording proper.

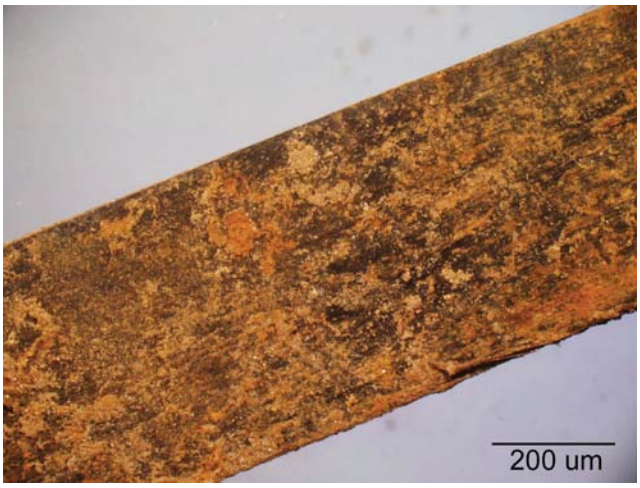

Figure 3. Close-up view of the "smooth" side of the cording. Note that while slight longitudinal striations are evident, no individual fibers are distinguishable.

rather stiff but not perfectly straight; it is bent or curved in several places. The cording appears dark brown by reflected light, with some regions of golden brown or rust-colored adherent particles. One side of the cording shows texture, and individual fibers can be visualized and followed along the length of the cording (Figure 2). Together these fibers form the cording, running straight and roughly parallel to each other. In some areas several individual fibers are beginning to detach from the main body of the cording. In contrast, the obverse side of the cording appears very smooth, and while slight longitudinal striations are evident, individual fibers cannot be seen. This side of the cording is very flat and even, and also contains the majority of golden brown and rust-colored adherent particles (Figure 3).

A small piece of an individual fiber of the cording (already beginning to separate from the rest of the cording) was removed and mounted for polarized light observations (Figures 4A-C). By transmitted light, the fiber was dark brown to tan in color, appearing more darkly colored or opaque where it was thicker. More importantly, brown pigment granules (melanin) were visible, indicating that this fiber is a mammalian hair. The fiber's birefringence and sign of elongation are also consistent with hair. The diameter for all hairs that were observed ranged from 150-250 μm, indicating that this hair was not of human origin (typical human hair diameters have a range of about 40-120 μm).

The microscopical exam also shows that the sides of some of the hair fibers (Figure 4A) are somewhat uneven, and appear to show evidence of degradation or injury to the hair. These irregularities do not look like insect damage, as they are too slight, and appear indiscriminately across various cortical layers within the same area at the edge of the hair. In hairs subjected to insect damage there are cuspate lesions, "bite marks," that can be seen at the hairs' edges. The corset cording hairs simply looked a little roughened. Some corset cording hairs, however, did not show any apparent damage, and appeared to be smooth and unbroken. There was no evidence of fungal attack or growth on any of the hairs observed.

A close look at the textured side of the cording revealed the presence of a second type of fiber lying atop the straight parallel fibers, much smaller in diameter and with a twisted and irregular morphology (Figure 5). These fibers were removed using forceps and a tungsten needle, and then mounted for polarized light microscopy. The fibers are natural fibers, presumably textile fibers from the corset material, given the context of the case, and a cursory examination indicated they may possibly be flax (linen) or hemp due to the presence of cross-hatchings within the fibers.

Cross sections were made by hand on individual hairs as described in the previous section. The cross-sectional shape of these individual hairs ranged from perfectly circular to completely flattened. Severe degradation of the cuticle and some areas of the cortex were noted. The cuticle was detached or beginning to detach. Cortical cells showed signs of separation, and, interestingly, the melanin pigment granules appeared

Figure 4A

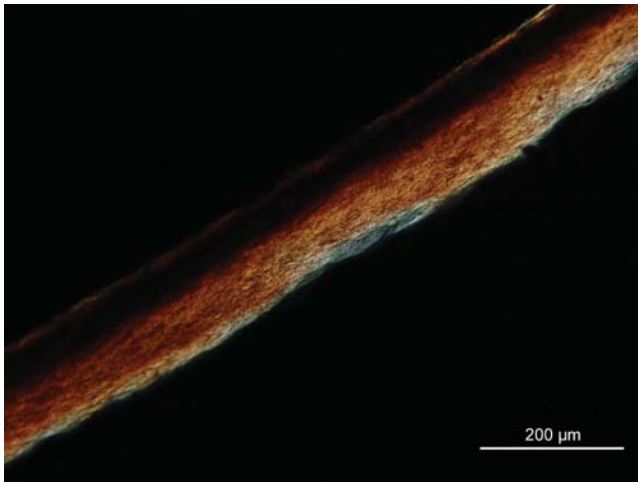

Figure 4B

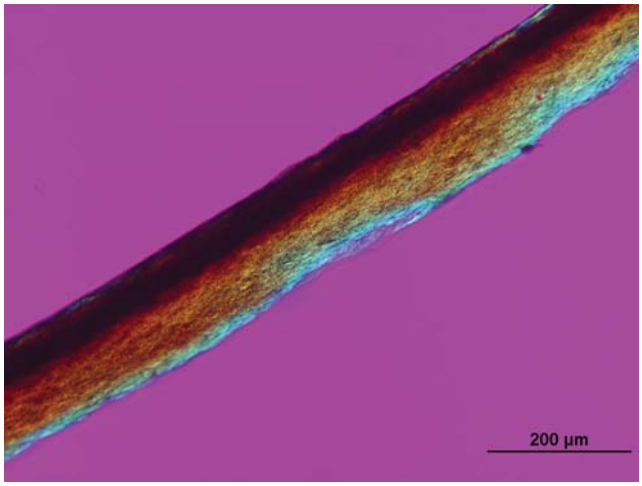

Figure 4C

Figures 4A-C. Polarized light images of individual corset cording fibers. A: plane polarized light. B: crossed polars. C: crossed polars with red 1 plate.

Figure 5. Close-up view of the textured side of the cording showing the presence of a second type of fiber lying atop the straight parallel fibers. These are likely textile fibers from the corset material itself.

to form concentric rings around the medulla (Figures 6A and 6B). Comparison to the cross section of a typical hair (Figure 7) shows stark differences.

Transverse cross sections were also made on the cording as a whole, rather than just individual fibers. Results were surprising, showing some hairs that appeared to have softened and flattened into the ribbon-like shape of the cording (Figure 7). Some individual hairs show medullary canals, but other, more flattened hairs, did not. Note that the hairs are flattened on only one side of the cording. This is the smooth side seen on the intact cording, and explains why individual hairs could not be visualized. The textured side shows hairs that have a nearly circular cross-section and are easily individualized, which was clearly seen macroscopically and with the stereomicroscope on the intact cording.

Scale casts were also performed on several individual hairs in an attempt towards species determination. Species determination is typically based on the shape and arrangement of the cuticle scales, as well as the morphology of the medullary cells and relative size of the medulla. Scale casts that were performed on numerous hairs indicated that scales were no longer

Figure 6A

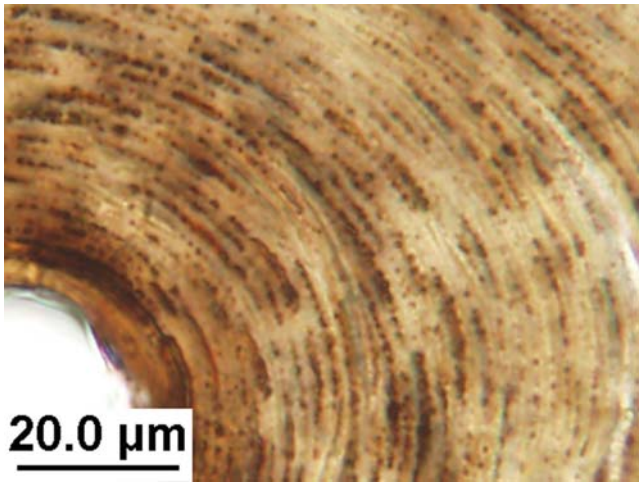

Figure 6B

Figures 6A and B. Polarized light images of cross-sectional view of individual fiber from corset cording. A: cross section overview. Note the arrangement of melanin into concentric rings surrounding the medulla. B: close-up of melanin particles.

present or intact. And unfortunately, because of the advanced state of degradation of the medulla, cell morphology could not be observed and the medullary ratio (defined as the diameter of medulla/diameter of hair, and often used to distinguish between human or nonhuman hairs) could not be measured reliably.

Chloroform was used in an attempt to extract any binder that might be present in the cording. When a small piece of cording was placed in a bath of chloroform, it did not break up in either room temperature or gently heated chloroform, indicating that binder was not present. Nonetheless, the supernatant was spotted onto a KBr salt plate for transmitted FTIR microspectroscopy. No spectra were obtained, signifying the absence of binder in the cording.

Figure 7. Cross section of a typical hair. Note the random, irregular distribution of melanin, as well as the smooth cuticle.

DISCUSSION

The fibers that collectively make up the corset cording are mammalian hairs. However, because the hairs no longer have scales or intact medullary cells, and most of the hairs' cross sections have been distorted, an accurate species determination is impossible. The thicknesses of the hairs, however, do indicate a nonhuman origin, and one possibility is horse hair. Horse hair (tail or mane) was a very common textile fiber during the mid-1800s.

According to Matthews (1947), mane hair has a diameter range of 50-200 µm, while tail hair ranges from 75-280 µm. These thicknesses are consistent with those seen in the cording fibers. Furthermore, horse hair has a circular cross section (3). Several of the hairs seen in the cording whole-mount cross section do show circular cross sections. Horse hair from the tail or mane is therefore a potential source, but it should be emphasized that it is not the only possibility.

Considering that the corset cording is over 150 years old, the hairs are in relatively good condition, with no evidence of fungal growth on any of the hairs that were examined. It has been reported that hair will become subject to fungal attack when buried in soil (4) or in a lead coffin (5). By transmitted light microscopy

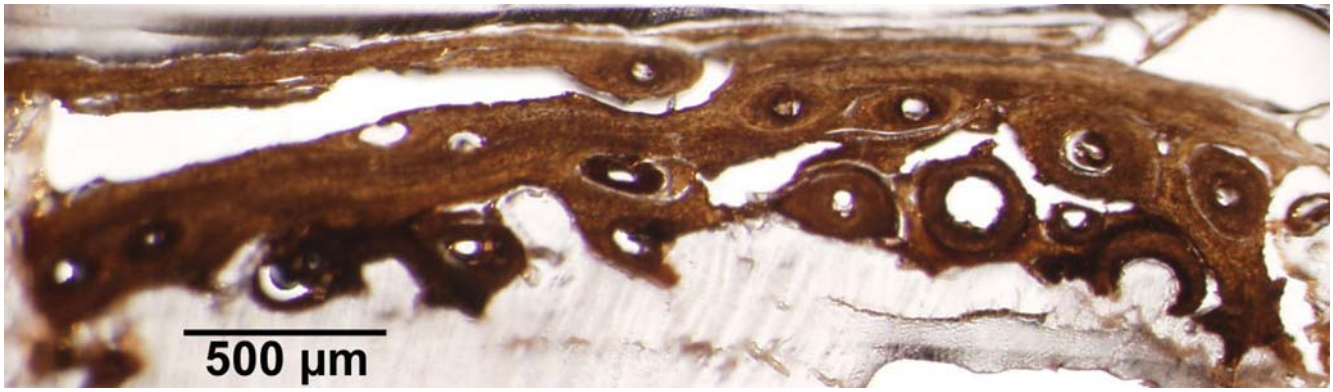

Figure 8. Transverse cross section of whole corset cording. Note that some hairs appear to have softened and flattened into the ribbon-like shape of the cording, while others remain rounded.

fungal tunnels can be seen as dark, narrow, transverse lines along the width of the hair, and are typically simple and unbranched. In at least one documented case, fungal tunneling was seen in some hairs but not others from the same body (buried for three weeks), possibly because clothing prevented fungal spores from accessing the hairs (4). Ambient temperature and environmental moisture are other factors that may affect the presence and extent of fungal tunneling (5). The use of metal coffins (as was the case here) apparently does tend to restrict microbial activity (6). Furthermore, the corset cording would have been sewn into and potentially protected from spores by several layers of fabric, so it is not unrealistic that no fungal activity was seen on these hairs.

Though there was no fungal growth, these hairs did experience some degradation, as evidenced by the arrangement of the melanin granules in concentric rings and the poor state of the cuticle seen in cross sections, as well as the lack of cuticle scales and irregular borders along the length of some hairs. One study of hair degradation over time found that once the cuticle layer is gone, the surface of the hair will appear rougher (7). This is consistent with the findings in the corset cording hairs.

In the Chang study, tissue losses were seen in the medulla as well, and continued into the area of the cortex bordering the medulla as degradation persisted. Additionally, spaces between the macrofibrils of the cortical cells could be observed by transmission electron microscopy (TEM). These spaces increased with prolonged degradation times (7). This differential degradation of the hair is further manifested in the fact that the pigment granules seem to be unaffected (6). The concentric appearance of the melanin may be due to spaces that formed between macrofibrils, which allowed the tissue to separate into distinct layers. These layers would be visualized microscopically by the dark melanin granules in the concentric orientation. The Chang study did not mention whether any pattern was seen in degraded cross sections.

The flattening and distortion of the fibers on one side of the cording is possibly an artifact of the degradation of the hairs, perhaps from contact with the immediate environment within the casket. Another cause could be the use of the cording within the corset during the wearer's lifetime; potentially, the hairs may have simply become flattened from continued use in the corset.

CONCLUSIONS

The fibers making up the cording are mammalian hairs. Species determination is not possible given the severe degradation of the hairs. However, based on thickness alone, the hair is nonhuman. Horse hair (tail or mane) was a very common textile fiber during the mid-1800s and has a thickness consistent with that of the cording fibers. Therefore, this is a potential source, but it is not the only possibility.

The degree of degradation of the hair is quite low considering its age. This is likely due to conditions within the iron casket, which limited the fungal and microbial activity, as well as the possibility that the cording was somewhat protected by the fabric of the corset itself.

ACKNOWLEDGEMENTS

The author wishes to thank Stephanie L. Golda and Dr. Daniel J. Wescott, both of the University of Mis-

souri, Department of Anthropology, for providing the sample of corset cording for analysis.

REFERENCES

1. Golda, S.D. and Wescott, D.J. "The Effects of Corset Wearing on the Skeleton: An Archaeological Case Study from Machpelah Cemetery in Lexington, Missouri." Unpublished master's degree thesis, Department of Anthropology, University of Missouri, Columbia (no date).

2. Palenik, S.J. Microtrace LLC, Elgin, IL. Personal communication, August 2008.

3. Matthews, J.M. *Textile Fibers* (5th ed.). John Wiley & Sons: New York, pp 650-652, 1947.

4. DeGaetano, D.H., Kempton, J.B., and Rowe, W.F. "Fungal Tunneling of Hair from a Buried Body." *J. Forensic Sci.*, **37,** pp 1048-1054, 1992.

5. Rowe, W.F. "Biodegration of Hairs and Fibers." *Forensic Taphonomy: the Postmortem Fate of Human Remains.* Haglund, W.D. and Sorg, M.H., (eds.). CRC Press: Boca Raton, FL, 1997.

6. Wilson, A.S. "The Decomposition of Hair in the Buried Body Environment." *Soil Analysis in Forensic Taphonomy*; Tibbett, M., and Carter, D.O. (eds.). Taylor & Francis Group: Boca Raton, FL, pp 123-151, 2008.

7. Chang, B.S., Hong, W.S., Lee, E., Yeo, S.M., Bang, I.S., Chung, Y.H., Lim, D.S., Mun, G.H., Kim, J., Park, S.O., and Shin, D.H. "Ultramicroscopic Observations on Morphological Changes in Hair During 25 Years of Weathering." *Forensic Sci. Int.*, **151,** pp 193-200, 2005.