Observations on the Use of OCT to Examine the Varnish Layer of Paintings

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PURPOSE

The purpose of this study is to demonstrate that Optical Coherence Tomography (OCT) can be used to:
1) Measure the varnish layer thickness of paintings, and
2) Verify that the varnish layer has been removed after laser ablation-based conservation efforts.

INTRODUCTION

To restore the original intent of the artist, art conservation is moving towards an increased use of laser ablation to remove varnish layers, which have become encrusted with contaminants or have been otherwise altered over the years.13. It should be possible to guide the restoration process with imaging modalities that provide information about the varnish layer. In paintings where the encrustation has not rendered the varnish completely opaque, OCT has the potential to provide details about the structure and thickness of the varnish layer in a non-invasive manner.12,11.

BACKGROUND

Optical coherence tomography enables fast, noninvasive, high resolution, three-dimensional imaging of the internal microstructure of weakly scattering objects. Conventional OCT systems are coherence-gated interferometers wherein the optical measurement technique known as low coherence interferometry is used to measure the magnitude and echo time delay of backscattered light. In its simplest manifestation, time-domain OCT (TD-OCT), the illumination is split and sent to both a reference arm and to the sample. Light returning from the sample interferes with light returning from the reference arm, and interference fringes are observed that provide the reference and sample path lengths are matched to within the coherence length of the source. Scanning the reference path length results in a series of interference fringes that correspond to different depths in the sample. The photodetector signal is demodulated to reconstruct each A-scan.

Further, prior work (Figure 1) has shown that using lasers for art conservation may offer advantages over conventional methods with solvents and scalps12. Some contaminants and encrustations require very strong solvents or cannot be removed with a solvent without removing some of the paint itself: solvent may saturate the substrate, cause it to swell, materials from the substrate may leach into the solvent, and the conservator may be exposed to toxic fumes from the solvent.

RESULTS

Figure 6. OCT images before and after varnish removal. Note: ESEM imaging required removal of a small (approximately 1 mm²) portion of the painting. Measured varnish layer thickness in three locations: 13.09 μm, 11.87 μm, and 13.24 μm. In the image acquire after Er:YAG removal, the surface of the paint appears devoid of varnish, and the texture of the surface of the paint appears fluid-like with pockets of smooth areas. Varnish layer thickness was 10.8 ± 3.8 μm and 12.7 ± 0.7 μm measured by OCT and ESEM respectively. Complete varnish layer removal was observed in several regions of paintings after laser treatment with occasional residual varnish in regions of significant surface topological variation. Additionally, the presence of over-paint and differences in penetration depth were observed in the OCT cross-sections.

CONCLUSIONS

• We believe that this is the first demonstration of the application of OCT to show that the varnish is removed by Er:YAG laser treatment.

• In conclusion, we demonstrate that OCT may provide a non-invasive technique that provides measures of the varnish layer and verification of its removal after laser ablation-based conservation efforts.

REFERENCES AND ACKNOWLEDGEMENTS