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Unravelling the Stone Age fishing net knots

3D-modelling the structure with micro-CT

ABSTRACT

This paper presents findings of Stone Age knots from the waterlogged Järvensuo 1 site in Humppila, Finland. The assumed fishing net knots were discovered by chance in soil samples taken from the site. A total of 16 knots made from tree bast materials were found, and these are presented here as material for 3D-modelling based on micro computed tomography (micro-CT) imaging.

Micro-CT is an advanced research method for heritage materials, enabling the study of complicated, layered or fine structures without interfering with the object – a non-invasive method. Micro-CT imaging reveals the inner structures of the target and enables combining the images to create a 3D-model of the object. Here, micro-CT is used to study the knot structures, thereby enhancing our understanding of Stone Age craft making, net fishing traditions and the early uses of tree bast materials.

Keywords: Stone Age; fishing net; knots; micro-CT; 3D-modelling.

INTRODUCTION

The lake settlement of Järvensuo 1 is situated in Humppila in south-west Finland. The site was excavated preliminarily in 1980 (Siiriäinen, 1987; Koivisto 2021) and revisited in 2020 and 2021 as part of a wetland archaeological project (*Perish and Fade Away*) at the University of Turku. The waterlogged site has yielded rare organic artefacts and crafts enhancing our knowledge on the skills of the Stone Age societies of boreal Fennoscandia. Based on direct 14C dates, the site has been occupied for a considerable time during the Mesolithic and Neolithic periods, between c. 6000 and 2000 cal BC. Especially numerous fishing related materials highlight that the now overgrown lake has served as an important procurement area for food and raw materials for Stone Age hunter-fisher-gatherers for several millennia (Koivisto et al., 2024).

In addition to the fishing gear and other functional objects, a unique wooden snake figurine was also found from the lakeshore (Koivisto & Lahelma, 2021), which seems to have had artistic or aesthetic value, or at least its function remains unknown. However, even the organic wrappings and ties of the fishing net sinker stones are made with such piety that some general views about the level of craftsmanship among the Stone Age populations of boreal Fennoscandia need to be re-evaluated.

Our presentation will concern a section of an ongoing project entitled *Artisans of the Stone Age*, funded by the Finnish Cultural Foundation, where the material culture, crafting skills and raw materials of the Järvensuo 1 site are studied multidisciplinary in order to shed new light on the Mesolithic and Neolithic lifeways in boreal Fennoscandia. Our focus here is on a study material comprising 16 fishing net knots that were found through screening of the soil samples for palaeobotanical studies. We will present and discuss how micro-CT (micro computed tomography) was utilised in examining the knot structures through minimally invasive imaging technique. 3D-models were created from the structures without interfering or unravelling the original finds. This allowed us to identify different knot types and other characteristics in the material.

One of the oldest fishing nets in the world, the Antrea net (Pälsi, 1920), has been directly ¹⁴C dated to c. 8400 cal BC (Miettinen et al., 2008, 78). Of the Järvensuo 1 materials, one knot has been directly ¹⁴C dated to 4933-4725 cal BC (Koivisto et al. 2024, 3), placing it in the Mesolithic-Neolithic transition and thus over 3000 years younger than the Antrea net. The material identification of the Antrea net (Miettinen et al., 2008, 84) showed that it was made of willow (*Salix* sp.) bast cordage with a knot type known as a weaver's knot or a sheet bend (Fi. Jalussolmu or Ryssänsolmu) (Pälsi, 1920; Nurminen, 2020, 34-35). Kaaronen et al. (2025, 14) have recently shown that these are actually one and the same knot type, only visualised from opposite directions. The same knot type is still used in present-day handwoven fishing nets, and it is reasonable to assume that it can be identified in the Järvensuo 1 samples too.

The Järvensuo 1 knots are made of tree bast fibers, and the material identification is done in another section of the research project. On the basis of plant macrofossil and pollen analyses, and comparable literature, we could narrow down the possibilities to species of *Salix*, *Tilia*, *Populus*, *Prunus* and *Juniper*. The diameter of the knots varies from 2 mm to 10 mm (Figures 1. and 2.). Preserved in waterlogged environment, and after excavation in ethanol, the knots are, at least superficially, in a surprisingly good condition, at least for the time being.



Figure 1. Knot 10354:49c imaged with Dino-Lite. Image: Jenni A. Suomela



Figure 2. Knot 10354:49a imaged with Dino-Lite. Image: Jenni A. Suomela

MICRO-CT IMAGING

Computed tomography (CT) is an imaging technique routinely utilised in hospital environments. Advantages of this non-invasive method has been in research of heritage materials and objects. For

example, children's coffins have been imaged with CT (Lipkin et al., 2021), and more detailed resolution micro-CT has been used in studying archaeological textile structures (Suomela et al., 2022). With nano-CT it is possible to study fibre characteristics (Lipkin et al., 2023) and synchrotron powered micro-CT allows to study wholesale mummies in great detail (Porcier et al., 2019). All these without interfering the target and its structures and with possibility to study both surface and inner structures.

In micro-CT imaging, 2D projection images of the target are taken while rotating the target around a rotation axis. Typically, thousands of such images are taken, and they are then used to reconstruct cross sectional slices, with isotropic voxel size (roughly the resolution) that depends on the purpose. In an earlier study, we tested the possibility to use micro-CT in visualising bast fibre characteristics (Suomela et al. 2022). In that study, we applied voxel size as fine as 2 μm , creating more than 1000 cross sectional images from a few mm long sample. This stack of images can be merged to create a 3D-model of the sample. The image voxels are visualized as grayscale, and the brightness depends on the local attenuation of X-rays in each voxel. The attenuation depends on the density and effective atomic number of the material in each location.

In this project, we wanted to study the structure of the Neolithic knots without unravelling them. The imaging was done with voxel size of 7.5 to 24 μm , depending on the size of the knot. This allowed us to study the structure of the knot itself. As small as possible (> 2mm) samples were taken from the knots to examine and possibly identify the material with polarised light microscopy methods.

The micro-CT images were processed with Fiji ImageJ open-source software to visualise the cords' path in forming the knot. From circa every fifth image, the outlines of the cord were segmented as region of interest (ROI). After giving both cords different colour values and combining the stack to 3D-model, the outcome can be viewed from every direction. The structure of the knot and knot type accordingly can be studied as easily as from a real-life knot made with two different coloured cords (Video 1).

[Link to the video.](#)

Video 1. Micro-CT imaging and segmentation of knot 1109:33b was made by Heikki Suhonen.

DISCUSSION

Extracting bast fibres from tree bark requires specific knowhow and capability for careful project planning. We have potentially underestimated the level of skill of Stone Age artisans, which of course is due to the general scarcity of organic materials in acidic, micro-organism rich boreal soils. Making a cord from tree bast is a long process starting from a correct timing, suitable tree, retting place, duration, extraction and twisting (Loudon et al., 2023, 9). Our preliminary results reveal various types of knots, including the overhand knot (Figure 1.) and the sheet bend (Figure 2.). Simple knot structures can easily be untangled from Dino-Lite images, but more complicated knots, such as the sheet bend shown in Figure 2, benefit greatly from 3D-modelling. Creating 3D-models from micro-CT images is time consuming and requires specific skills from the researcher. Nevertheless, CT imaging techniques enable the non-invasive research of archaeological and heritage materials, which is considered an ethical objective of future research.

Sheet bend is a type of knot that is not easily made by an accident. Weaving a fishing net with tree bast cord and sheet bend knots require systematic working. All these units are enabled only by inherited knowledge and skill (Hurcombe, 2014, 6-7). Apparently, these skills were valued so profoundly that they were passed on from generation to generation for more than 10 000 years. But now, just in few generations we have discarded them as useless. The emerging question for today is: Are we sure this is the right direction?

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