CHARACTERIZING THE MICROMORPHOLOGY OF CUT MARKS INFLICTED BY OLDOWAN AND ACHEULEAN STONE TECHNOLOGIES USING HIGH-RESOLUTION 3-D SCANNING

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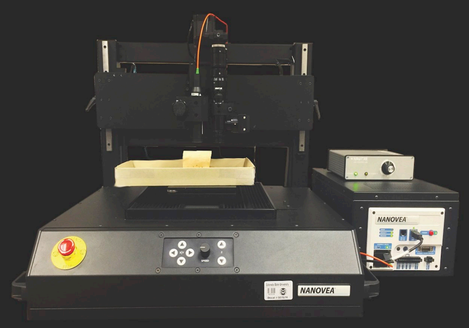
RESEARCH QUESTION

Can variations in 3-D micromorphological features discriminate between cut marks made by flakes and handaxes?



BACKGROUND

Cut marks on animal bones suggest the simple core and flake technology used by hominins was effective for removing flesh from large mammal carcasses. However, 1.7 mya Acheulean technology, characterized by large bifacially flaked handaxes, appears on the landscape and it is unclear whether these new tools were used for a similar purpose or developed for different tasks. One of the best ways to link specific tool types to butchery by hominins is through the traces they leave behind on fossils. Archaeologists have used different imaging technologies such as scanning electron microscopy and 3-D laser scanning in an effort to differentiate cut marks from other bone modifying agents [1, 2, 3, 4, 5, 6]. However, past attempts to identify tool induced variations in the micromorphological characteristics of cut marks have been mostly unsuccessful due to a lack of control over variables such as carcass size and the angle at which the tool was held [7].

METHODS

- Cut marks were created by TLK using chert flakes and chert handaxes along the shafts of 6 sectioned cow femurs, controlling for variations in the angle of tool impact and applied pressure.
- 3-D reconstructions of cut marks were produced using a Nanovea ST400 white-light confocal profilometer.
- 3-D reconstructions of cut marks were processed and measured using Digital Surf's Mountains® software.

RESULTS

		3-D MEASUREMENTS							PROFILE MEASUREMENTS					RATIOS			
		VOLUME (μm^3)	SURFACE AREA (μm^2)	MAXIMUM DEPTH (μm)	MEAN DEPTH (μm)	MAXIMUM LENGTH (μm)	MAXIMUM WIDTH (μm)	MAXIMUM DEPTH (μm)	AREA (μm^2)	WIDTH (μm)	ROUGHNESS (R_a)	ANGLE (°)	RADIUS (μm)	WIDTH / DEPTH	VOLUME / LENGTH (μm^3)	LENGTH / WIDTH	(ROUGHNESS / AREA) * 10000 ($R_a/\mu m^2$)
FLAKE	Mean	68889012	3315355.0	98.0	30.4	17346.9	427.6	93.5	14618.0	334.6	2.6	114.9	454.3	5.0	5003.0	49.0	3.2
	Median	53525000	1903662.4	87.0	26.5	13151.8	419.6	85.1	11009.5	287.5	1.8	125.9	214.8	4.4	4513.0	32.6	1.9
	Standard Deviation	58000159	6537304.8	47.3	16.4	16911.7	151.5	47.2	12013.5	183.1	2.1	34.9	567.2	1.9	4221.5	66.9	3.6
HANDAXE	Mean	147213980	4126722.4	85.4	27.6	10923.3	621.3	81.5	23043.0	494.5	2.7	138.8	768.5	7.4	10009.9	18.4	2.8
	Median	51115000	2423187.4	78.7	27.3	9215.3	582.0	76.6	15880.6	442.5	2.3	137.2	523.4	7.5	6850.8	16.0	1.5
	Standard Deviation	218709392	4772545.8	36.8	12.7	6556.0	298.3	41.7	22926.6	276.7	1.6	16.6	777.4	2.1	9237.1	9.1	3.6
p-value (*t*-test)		0.14	0.66	0.35	0.54	0.13	0.02	0.40	0.16	0.04	0.98	0.01	0.16	<0.01	0.04	0.1	0.6

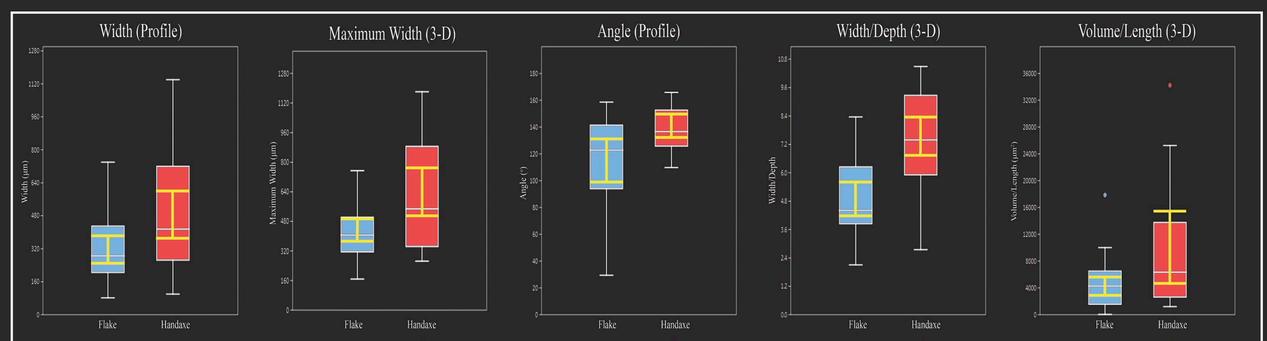


Figure 1) Boxplots showing statistically significant differences in the measurements of cut marks made by handaxes and flakes (Yellow bars represent 95% confidence intervals).

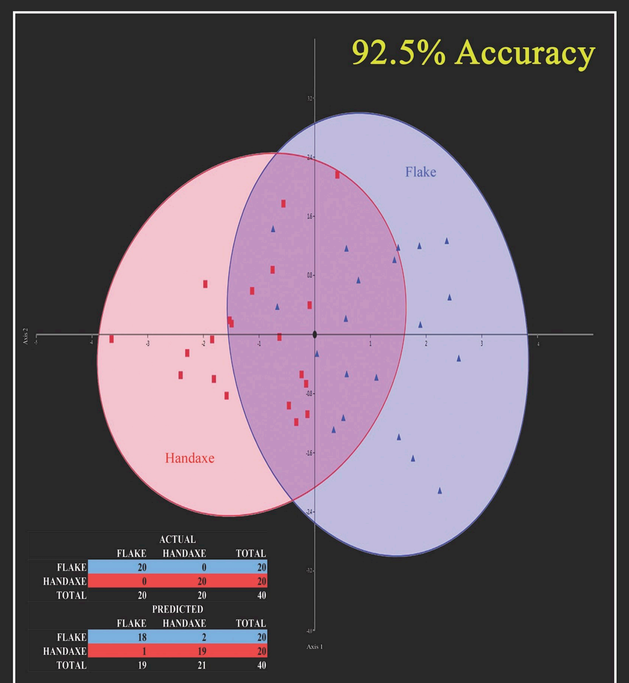


Figure 3) Discriminant analysis of measurements of handaxe and flake cut marks. Table shows predicted and actual confusion matrices between tool technologies (Red squares each represent one handaxe cut mark, Blue triangles each represent one flake cut mark; Ellipses represent 95% confidence intervals for cut marks made by each tool type).

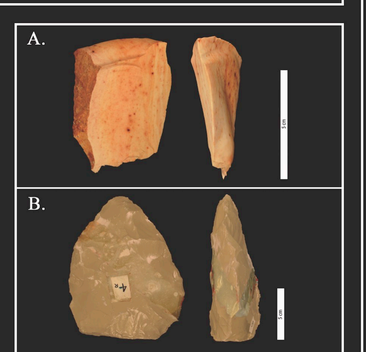


Figure 2) Chert flake (A.) and chert handaxe (B.) used for butchering experiments.

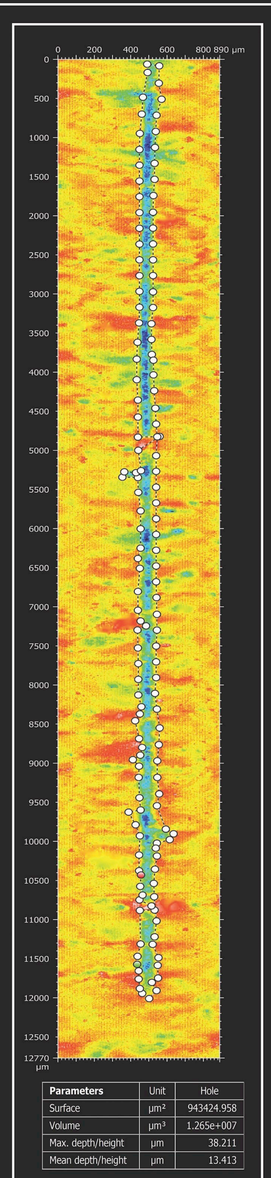


Figure 5) Volume calculation for a flake cut mark.

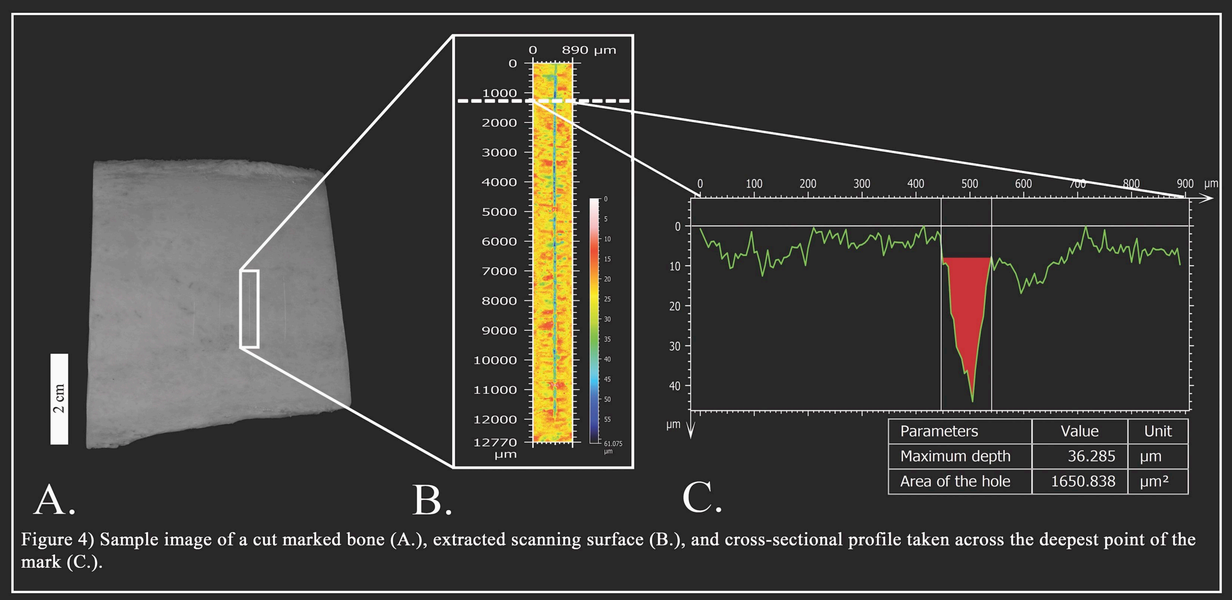


Figure 4) Sample image of a cut marked bone (A.), extracted scanning surface (B.), and cross-sectional profile taken across the deepest point of the mark (C.).

DISCUSSION AND CONCLUSION

- A discriminate analysis test using a subset of the measured variables was capable of distinguishing cut marks made by flakes from cut marks made by handaxes with 92.5% accuracy. It was noted that flake cut marks tended to have smaller cross-sectional width and angles compared to handaxe cut marks.
- Future research will expand the size and diversity of the database by including more tool types and raw materials in the sample. This database will be applied in interpretations of cut marks on fossilized bones dating to the Oldowan/Acheulean transition.

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