STONES, BONES, AND ANTLER TINES: 
A COMPARISON OF MIDWEST ARROW POINTS

By

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Cultures in the Midwest such as the Mississippian and Oneota crafted projectiles from raw materials ranging from local stone to exotic materials, bone and antler. This thesis is a study of differences in the nature of raw materials, as well as the advantages and disadvantages of each. Methods were employed to measure time invested in manufacturing and hafting each projectile point, as well as how each point performed when used against a target. As a result, this thesis was able to better understand the properties of each type, possibly determining the use of each. In general, stone points had the lowest cost of time to create, however, organic points required less skill. In terms of performance, the wounds caused by lithic points and distal phalanges are suitable for harvesting medium and large game, while antler tine points are effective against both medium and small game.
ACKNOWLEDGEMENTS

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INTRODUCTION

Humans have been using stone tools for millions of years. However, in addition to locally available stone, humans have also turned to organic materials, chiefly bone, horn, or antler. This experiment is an attempt to explain the variety in raw materials within the archaeological record. More specifically, Midwestern traditions such as the Mississippian and the Oneota are known to have used arrowheads crafted from antler tine and bone in addition to both imported and locally available cherts and orthoquartzite. Given the variety of raw materials, there are numerous possibilities as to why each was utilized.

Depending on environmental conditions and what was locally available, an individual may be drawn to the most readily available material, with other materials being used as a standby. Some materials may be easier to work; manufacturing objects of any type involves a certain learning curve, so logically, most people would prefer a material that can be worked with relative ease. Efficiency in manufacturing may be a key factor; after all, most would prefer to produce as many projectiles as possible without expending more time and energy than necessary. Spiritual factors, such as the symbolism of harvesting an animal with a part of its own kind may be present, but are difficult to verify. There could also be a difference in effectiveness; a certain material may be preferential for the penetration it offers, or the amount of damage it is capable of causing inside the target. Yet another possibility is simply personal preference, due to how the individual learned to work material, or how a certain material performs.

This experiment is an attempt to answer questions concerning four materials: Prairie Du Chien chert, a variable and often low-quality material commonly utilized in the Driftless area of
Western Wisconsin; Hixton Silicified Sandstone, a material similar to orthoquartzite, that is sourced to the Silver Mound Site in Jackson County, Wisconsin, and is prized for its consistency and workability; antler tine from the white-tail deer, as well as the third phalanx of the white-tail deer. Because aesthetics such as personal preference or spiritual situations requiring a certain material cannot be verified by this experiment, this test is mainly focused on the tangible aspects surrounding each point. The experimental process employed aboriginal methods of toolmaking in order to understand the properties of each raw material, specifically, efficiency in manufacture. In addition, a ballistics test was used in order to measure the effectiveness of each material.
BACKGROUND

The Mississippian Culture

The Mississippian culture was most prominent in the Midwest from about A.D. 1050 to A.D. 1300. Traces of this lifestyle began to emerge around A.D. 800, and in an event often dubbed the ‘Big Bang’, exploded across the Midwest around A.D. 1050. The end result was a complex society centered around what was the largest prehistoric site in North America, known as Cahokia. It is located east of what is now St. Louis and is estimated to have been home to about twenty thousand individuals at its peak (Mehrer 1995).

Although the Mississippian culture tended to have more influence in the present-day southeastern United States and lower Midwest, there were Mississippian-influenced towns located as far north as Red Wing, Minnesota. Mississippian sites are characterized by cone-shaped burial mounds and flat, square platform mounds, probably to be used as ceremonial centers and housing for the ruling class. Public areas and elite grounds were separated by maze-like palisades of logs covered in wattle and daub, complete with guard towers. The largest platform mound at Cahokia measures over a hundred feet high, and covers fourteen acres. However, due to many factors, possibly including environmental stress brought on by years of unusually cold conditions, the Mississippian influence in the Midwest collapsed shortly before A.D. 1300. All of the northern locales, including Cahokia, were abandoned, and the culture itself receded into the Southeast until contact with Europeans (Milner 2004).

During their heyday, Mississippian-influenced communities in the Midwest enjoyed being part of a massive trade network. Of particular interest to this thesis is a burial within
Cahokia known as Mound 72. Believed to be the burial of an elite, the main burial contained a male resting on a bed constructed of thousands of marine shell beads, surrounded by sacrificial victims. Also present were several bundles of arrows, each tipped with a point made either of antler, or a triple-notched tip made out of stone from several areas in which the Mississippians had influence. One bundle contained arrowheads made of Hixton Silicified Sandstone, which is also reviewed by this thesis (Stoltman 1991).

The Oneota

The Oneota culture emerged alongside the Mississippian culture, and continued into periods of contact with European settlers. This society is more of a northern focus; the expanse of these groups was in southern Wisconsin, Iowa, and northern Illinois, and expands into Nebraska, Michigan, and South Dakota. However, unlike their stratified southern counterparts, the Oneota never built ceremonial centers or developed formally ranked societies; instead, they lived in farming villages (Birmingham and Eisenberg 2000).

Oneota sites generally consist of longhouses, as well as pits used for storing food, which were later used as refuse pits. The longhouses were without doubt housing for extended families, since the shell-tempered pottery associated with them is capable of cooking several gallons of food at a time. This culture was heavily dependent on agriculture. Their most important crops were corn, beans, and squash, which were grown in ridged fields surrounding the village (Theler and Boszhardt 2003). Hunting was also important, as illustrated by the large amounts of deer and bison remains present at village sites (Theler 1989).
Projectile Points

One type of projectile point used by the Mississippian and Oneota traditions includes the style known as Madison Triangular (Figure 1). Madison Triangular points emerge in the archaeological record around A.D. 800. As the name would imply, the overall shape is triangular, although many variations in shape and size have been recorded. These points tend to be well-made, from both local cherts and silicified sandstone (Boszhardt 2003).

![Madison Triangular Points](image)

Figure 1. Madison Triangular Points to be tested. The top row is made from Hixton Silicified Sandstone, the bottom row is Prairie Du Chien Chert.

Projectile points made of antler tine are sometimes recovered at Oneota sites (Figure 2). Their general shape is similar to that of a traffic cone; the distal portions of the antler are grooved, snapped off, and hollowed (Theler 1989). Aside from stone and antler tine, some sites also include socketed points made from the third phalanx of a white-tail deer (Figure 3). This is
the bone directly below the hoof, which is typically ignored due to its low marrow content. It is occasionally modified into tools (Theler 1994). Although it is tempting to be drawn to a conclusion based on quantifying organic arrowheads against stone ones, this study will make no such effort. Due to the fact that the Midwest has a relatively humid climate, the soils tend to be fairly acidic, thus, bone and other organic materials do not preserve well (Brady and Weil 2008).

Based on ethnographic records compiled by Ellis (1997), hunters tended to use stone points for hunting medium to large game, while using points made of organic materials when hunting small game or waging war. Stone points have a broad, thin cross-section with sharp edges, thus, they cause a great deal of bleeding and internal damage as they slice through their target. The profile of an organic point delivers more blunt force than slicing power, making it ideal for hunting smaller animals. Since the object of war wasn’t necessarily causing fatalities, killing force may not be necessary. Instead, many Native American groups covered their war arrows with ‘poison’, which was in reality a wide variety of infection-causing agents, such as blood or urine. In cases like this, lethality may have taken a secondary role after intimidation. Also, special circumstances, such as hunting waterfowl, may call for arrows with points made from light material to avoid sinking after a missed shot, which would result in a total loss of the arrow.
Figure 2. Antler tine points after testing. Note #4 and #5 are broken, exposing the socket on the proximal end.

Figure 3. Distal phalanges of white-tail deer, crafted into projectile points.
Raw Materials

Of the many things that may determine how people adapt to various locales, one of the most important is what raw materials are locally available. There are scores of local cherts and orthoquartzites across the Midwest, not to mention select sources of other desirable raw material. If suitable raw material was not available at certain locations, there were options; chiefly, make do with the local varieties, or import better quality raw material from another location, as illustrated by several Oneota sites in the La Crosse, WI area, including the Tremaine Site which contained large amounts of chert from Missouri, Minnesota, and Iowa (Moffat 1994).

The first raw material to be covered in this experiment is known as Prairie Du Chien chert (PDC) and is very common in Western Wisconsin (Klawiter 2000) (Figure 4). It was one of the main lithic resources in the region. Coloration ranges from tan to dark gray. Generally found as inclusions within Late Ordovician carbonate rock, or as nodules associated with the aforementioned carbonic formations. Prairie Du Chien chert occurs in two varieties, Oneota and Shakopee. The Oneota formations tend to have a smooth, marbled appearance, while the Shakopee variety is oolitic and has a more coarse texture. Both types of PDC vary in quality, but are generally considered to be low quality (Morrow 1994).
Figure 4. Nodule of Prairie Du Chien chert. Note the oolites and unusual grain patterns.

Hixton Silicified Sandstone is found at a site in Jackson County, Wisconsin, mainly at a ridge known as Silver Mound. The name comes from legends of a lost silver mine, which early settlers searched for in vain. Hixton Silicified Sandstone is similar to orthoquartzite, and has a variety of color variation. The most common is white (Figure 5), but other hues known to occur include violet, dark brown, yellow, red, and tan (Behm 1984). Hixton was favored for its workability, due to the fact that it has a small granule size and is well cemented. It has been used since the earliest occupation of the area, during Paleoindian times over twelve thousand years ago. The stone occurs both in outcrops along the hills, and in the bedrock. In order to quarry this variety of silicified sandstone, pits were cut into the hill, and large stones were used to break up the bedrock that contained the desired material. The broken pieces were then gathered up, and worked into cores that were easy to carry, thereby isolating the best material, which was to be taken all over the Midwest (Brown 1984).
Experiments similar to the present study have demonstrated that certain materials are more suited to particular situations. Those experiments were conducted by S. T. Pope and are outlined by Knecht in a review of projectiles (1997). They demonstrated that penetration is not a key factor in arrow technology, as this depends more on the bow. Instead, the materials used for the point are the largest variable. In the arrow tests, Pope noted that stone points caused more lacerations within the target, but organic points had a longer service life and were easier to curate should they become dull. This would suggest that lithic weapons are better suited for one-time use against large game, while organic tips are ideal for repeated use against various game sizes.

Figure 5. Small sample of Hixton Silicified Sandstone. Note the consistency in grain size and well-formed silica concretions binding the grains together.
METHODOLOGY

Given the variety in raw materials for each locale occupied by the aforementioned cultures, this study will focus on four. As mentioned earlier, it is believed that the tangible property of each material is the determining factor in how materials and points are employed. Since it is entirely possible to measure the workability, skill, and time required to work a usable product out of the media, the first part of this experiment focused on exactly that topic. In the second part, using a simulated game animal, this study determined the amount of damage caused by each particular point type in terms of depth and cross-section.

Manufacture

In order to determine whether or not the amount of time invested in each projectile point is a factor in why each was used in the past, several points were manufactured using aboriginal methods. By means of a stopwatch, a running total was logged for every raw material. Only the actual labor spent on examining material for quality, workability, and the actual manufacture of the projectiles themselves was logged; rest breaks were not counted towards the grand total.

To ensure the data collected on the manufacture of Madison Triangular points is accurate, the help of a proficient flintknapper, Ryan Letterly, was enlisted. Using Prairie Du Chien chert quarried near his residence, as well as Hixton Silicified Sandstone provided by the Mississippi Valley Archaeology Center, we created five arrow tips of each stone type. Flintknapping has a relatively steep learning curve, although it seems to be a simple concept; being one of the main methods of stone tool making. The process involves systematically breaking and reducing
suitable stone by striking it with percussive force, and using thin tools to apply pressure to edges, effectively ‘flaking’ the stone into final form.

Due to the relatively lower skill level required to craft projectile points from bone, antler tine, and other organic materials, I created the tine and distal phalanx points by myself. The tine was cut using the groove and snap technique, which has been demonstrated within the archaeological record (Arzigian et al. 1989). This simply involved cutting a channel into the antler with a flake of silicified sandstone at the point where the break was desired. Once a suitable groove was cut around the circumference of the tine, the tip was broken by leaning it against a boulder and stomping on it (Figure 6). Having broken it as desired, the base was ground down against a flat piece of limestone. I discovered that the only way to generate enough force to drill the socket was to bore it by hand. I accomplished this by pressure-flaking a flake of silicified sandstone into an awl. I discovered that chert does not hold a sharp edge when used as a cutting or reaming tool. For this reason, I only used silicified sandstone when boring the socket. After the point was sufficiently hollowed to fit onto an arrow shaft, I turned back to the flat piece of limestone and ground the tip to a sharp point. I repeated this method again, after learning from Knecht’s description of manufacture (1997) that the tine is much more soft and manageable after being soaked. I let one tine soak in water for about three days, and used the wet tine as well.
The distal phalanx points were extracted from the deer’s ‘foot’ by using a flake of silicified sandstone to cut the bone away from the hoof, much like shelling an oyster (Figure 7). After being left to dry, a sharp cutting tool was used to remove the connective tissue. Once the sheathing around the bone was taken off, the final stage was nearly identical to that of the antler; a stone awl was used to drill the hole for hafting. This particular bone is hollow, thus, much less effort was needed to craft the socket compared to the tine. The phalanx was then sharpened on a piece of flat stone. Much like the antler, minimal shaping was involved; the bone is not modified dramatically.
Figure 7. Using a silicified sandstone blade to ‘shell’ the third phalanx from the hoof.

**Ballistics Testing**

The second part of this experiment deals with how points perform when they are actually used against a live target. Since the natural diversity of uses would in theory create an equally variable amount of applications and levels of damage caused, measures were taken in order to minimize the amount of variables within the experiment.

Addressing the issue of consistency, the arrows were fired from a modern compound bow. This bow type has a feature referred to as a ‘wall’, which prevents the arrow from being launched properly unless it is drawn back exactly thirty inches (Figure 8). The arrows themselves were modern, mass-produced carbon arrows. Although using a material such as hickory or willow would have been preferable in terms of staying true to aboriginal materials, time
constraints, material availability, the difficulty associated with making arrows consistently, and a lack of expertise prevented this.

Figure 8. The archer lining up to launch an arrow at ten meters.

Hafting material was generously supplied by the Mississippi Valley Archaeology Center. Trying to keep true to Native American techniques, the lithic projectile points were hafted to the arrows with sinew extracted from the tendons in the legs of the white-tail deer (Figure 9). The properties of the sinew make it an ideal material for this task. When soaked, sinew becomes very pliable and sticky, however, after being removed from water, it tends to shrink and harden as it dries out. By cutting long, thin strips and wrapping this hafting material around both the points and the arrows together, I was able to create a tight attachment without modern adhesive.
Figure 9. PDC arrowheads hafted to the arrows with sinew.

The arrow tips made out of organic material required a different approach, while still keeping true to excluding modern materials as much as possible. The fairly rounded profile of these projectile points made using sinew unpractical. Instead, animal glue, which is a relatively simple concoction made by boiling hooves, was used. A generous amount of glue was placed into the socket of each point, before being secured to the end of each arrow (Figure 10).
The ballistics target was a simple but effective setup (Figure 11). Because using a live animal as a test subject would have been illegal, and a carcass would have contained many variables in the form of bones and internal organs, our target was a simulated “deer body” constructed of two blocks of ballistics gel, which is a protein-based media used by law enforcement agencies to test damage caused by weapons. Placed end to end, the blocks had a total thickness of about 23 cm. These blocks were wrapped in a piece of tanned deer hide. The archer stood ten meters from the target when firing all arrows into the gel target.
Results of the ballistics test are quantified both by the depth of penetration, and noting the characteristics of the ‘wound’. Although it is tempting to only measure penetration, one must remember that game animals have finite dimensions, and the amount of damage caused within the depth of penetration may be far more important than the actual depth of the puncture.

**Predictions**

Initial predictions were that the higher quality Hixton material would be superior, both in terms of causing internal cutting damage due to the cross-section, and being the most cost-effective for the investment of time. Although the Prairie Du Chien chert is much lower in quality, it was thought that it might offer comparable internal damage, albeit at a higher cost in time taken to
work each projectile point. Following this trend, I predicted that the bone and antler tine arrow tips would penetrate the target to a depth comparable to that of the stone points, but would not cause as much damage, as they lack a broad, slicing cross-section. Also, they would probably strike with more blunt force. Finally, the crafting stage was bound to require more time, given the amount of cutting, drilling, and shaping required.
RESULTS

Manufacture

The end result of manufacturing each point varied by raw material, to say the least. The Prairie Du Chien chert was relatively difficult to work with, as expected. The inconsistencies and oolites proved to be a problem for a worker trying to rush the points. Working at a relaxed pace, the flintknapper was able to produce five points in about three hours and fifteen minutes.

The Hixton Silicified Sandstone was by far the easiest material to work with; it proved to be a much more forgiving media, and allowed working at a faster pace. Hixton owes much of its advantages to the consistency and structure. Since a faster pace and less care was demanded, only about a hundred and ten minutes were sacrificed to break off sizable pieces of the nodule, and shape them into Madison points.

The antler tine met our expectations of being easier to craft, but more time consuming overall. Cutting the end, boring the socket, and sharpening the tip of a dry piece of antler tine lasted a total of about seven hours, not counting rest time and time taken to sharpen the stone cutting tools. However, upon experimenting with the practice of soaking the tine prior to manufacture, the time of production was reduced to a more reasonable seventy minutes.

The distal phalanx of the deer is held tight beneath the hoof, by layers of connective tissue. Although a silicified sandstone blade was effective in cutting through the softer tissue, the hooves and tendons proved to be much tougher. Working around the bone to free it required about thirty minutes of cutting, and at times, an extra set of hands. Removing the surrounding tissue took several minutes. The bone itself proved to be much softer than the antler tine, and
was also hollow in the center. Therefore, drilling the socket and sharpening the tip took much less time. The total time involved in crafting a single distal phalanx point, from cutting into the tissue to sharpening the tip, was about sixty-five minutes.

**Ballistics Test**

The results of the ballistics test confirmed our suspicion that material type, mass, or dimensions would not play a significant role in the depth of penetration (Table 1). The PDC points were very effective, with a mean depth of 28cm. The Hixton Silicified Sandstone points produced a mean depth of 27.5cm. Out of curiosity on the archer’s part, a modern arrow tipped with a triple-bladed steel broadhead was fired into the target at his request. Much like the stone points, the broadhead made a clean cut through the gel, with a depth of about 29cm.

<table>
<thead>
<tr>
<th>Projectile Point</th>
<th>Length (mm)</th>
<th>Thickness x Width (mm)</th>
<th>Mass (g)</th>
<th>Wound depth (cm)</th>
<th>Wound traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDC #1</td>
<td>28.6</td>
<td>4.1x21.2</td>
<td>2.5</td>
<td>25.3</td>
<td>point detached, exited side of target</td>
</tr>
<tr>
<td>PDC #2</td>
<td>31</td>
<td>4.5x23.3</td>
<td>3.2</td>
<td>30</td>
<td>jagged, point detached</td>
</tr>
<tr>
<td>PDC #3</td>
<td>30</td>
<td>4.1x23.5</td>
<td>2.7</td>
<td>22.2</td>
<td>jagged, point detached and lodged in gel</td>
</tr>
<tr>
<td>PDC #4</td>
<td>17.9</td>
<td>1.7x13.7</td>
<td>0.5</td>
<td>31</td>
<td>thin cross-section, clean edges</td>
</tr>
<tr>
<td>PDC #5</td>
<td>28.3</td>
<td>5.4x22.9</td>
<td>2.9</td>
<td>31.8</td>
<td>jagged, point detached</td>
</tr>
<tr>
<td>Hixton #1</td>
<td>16.8</td>
<td>3x16</td>
<td>0.8</td>
<td>27.8</td>
<td>jagged edges</td>
</tr>
<tr>
<td>Hixton #2</td>
<td>22.3</td>
<td>5.5x18.7</td>
<td>1.7</td>
<td>27.3</td>
<td>jagged edges</td>
</tr>
<tr>
<td>Hixton #3</td>
<td>23.9</td>
<td>4x19.2</td>
<td>1.7</td>
<td>22</td>
<td>&quot;nosedive&quot; upon entry; large shock cavity</td>
</tr>
<tr>
<td>Hixton #4</td>
<td>21.9</td>
<td>5x21.2</td>
<td>2.3</td>
<td>27.7</td>
<td>clean edges</td>
</tr>
<tr>
<td>Hixton #5</td>
<td>26.9</td>
<td>4.9x17.5</td>
<td>2.3</td>
<td>32.5</td>
<td>clean edges</td>
</tr>
<tr>
<td>Tine #1</td>
<td>32</td>
<td>10.8</td>
<td>2</td>
<td>33.8</td>
<td>&quot;nosedive&quot;; point detached and lodged in gel</td>
</tr>
<tr>
<td>Tine #2</td>
<td>27</td>
<td>13.1</td>
<td>2.4</td>
<td>47.1</td>
<td>thin cross-section, clean edges</td>
</tr>
<tr>
<td>Tine #3</td>
<td>34.1</td>
<td>12.2</td>
<td>2.9</td>
<td>43.3</td>
<td>thin cross-section, clean edges</td>
</tr>
<tr>
<td>Tine #4</td>
<td>35.6</td>
<td>11.7</td>
<td>2.7</td>
<td>35.5</td>
<td>shattered point, lodged in gel</td>
</tr>
<tr>
<td>Tine #5</td>
<td>35.6</td>
<td>12.3</td>
<td>3.2</td>
<td>24.5</td>
<td>shattered point, split arrow</td>
</tr>
<tr>
<td>Phalanx #1</td>
<td>29.1</td>
<td>12.1x18.5</td>
<td>1.9</td>
<td>22.4</td>
<td>&quot;nosedive&quot; upon entry; large shock cavity</td>
</tr>
<tr>
<td>Phalanx #2</td>
<td>33.1</td>
<td>14x18</td>
<td>2</td>
<td>24.3</td>
<td>veered upwards, point detached upon exit</td>
</tr>
<tr>
<td>Phalanx #3</td>
<td>30.1</td>
<td>12.8x21.4</td>
<td>2.1</td>
<td>24.7</td>
<td>veered to right, triangular shock cavity</td>
</tr>
<tr>
<td>Phalanx #4</td>
<td>30.2</td>
<td>12.9x19.7</td>
<td>2.4</td>
<td>26.1</td>
<td>jagged, triangular shock cavity</td>
</tr>
<tr>
<td>Phalanx #5</td>
<td>30.1</td>
<td>11x18.4</td>
<td>1.9</td>
<td>31.7</td>
<td>point detached, lodged in target</td>
</tr>
<tr>
<td>Steel Broadhead</td>
<td>42.1</td>
<td>21.7</td>
<td>6.8</td>
<td>29</td>
<td>clean edges, triangular blade pattern</td>
</tr>
</tbody>
</table>

Table 1. Measurements of points and wound characteristics. Due to the round profile of the antler tine and broadhead, only the diameter is measured.
The characteristics of the wound caused by each arrow varied considerably. Generally speaking, the stone points made jagged wounds (Figure 12), which were at most a few millimeters wider than their maximum width at the base. The Hixton tended to produce cuts that were a bit more smooth on the edges, but did not vary considerably. Of particular interest were the wounds caused by PDC #1, Hixton #3, and PDC #3. Upon entering the target, the point on PDC #1 tore itself free of the arrow and partially exited the right side of the target (Figure 13). The arrow shattered and also exited the right side of the target, leaving a large gash where it sliced through. PDC #3 also detached itself from the arrow and lodged completely in the target, making almost a full turn as it did so (Figure 14). The arrow continued about ten centimeters into the target after being separated, splintering as it did so. PDC #2 and PDC #5 also detached themselves from the arrow, but exited through the back of the target. Hixton #3 made a ‘nosedive’ as it entered the target and stopped short of the other points’ depths, leaving a wide, twisted gap. Given the dimensions of the gel, nearly all of the points tested had potential to cause more damage to the target had it been larger.
Figure 12. Cross section of the target to show wound traits. The furthest ‘hit’ from the point of view is from the steel-tipped arrow, the paths closest were from PDC, the shots in the center are from Hixton.
Figure 13. PDC #1 after separating and veering out the side of the target.
Figure 14. PDC #3 after detaching from the arrow and doubling back into the ‘flesh’. The path the arrow continued along is visible to the right of the point.

The organic points did vary in effectiveness and wound traits. Contrary to what was expected, the antler tine points did have a higher depth of penetration than the stone tips, with a mean of 36.8 cm. However, these points did relatively little damage to the target; rather than leaving any type of shock cavity; the tines simply left a smooth gash where they struck (Figure 15). Point #1 detached as the arrow made a nosedive upon hitting the target, but did not create any torn edges; it only dropped a few centimeters before lodging in the gel (Figure 16). Point #4 shattered and lodged in the target while the arrow continued on a straight path. Point #5 also shattered, and the arrow split down the middle (Figure 17). Points #2 and #3 did not create noteworthy damage; instead, they made clean, straight paths.
Figure 15. Wound left by tine point #2. Note the lack of jagged edges, or damage beyond the dimensions of the point.
Figure 16. Point #1 after detaching from the arrow and nose-diving. Note the lack of serious tearing compared to stone points.
The damage caused by the distal phalanges was possibly the most varied and the most interesting. The depth of penetration did not deviate significantly from the stone points, with a mean of 25.8 cm. All of the points created a large, triangular shock cavity, with a great deal of tearing along the margins (Figure 18). However, the points had a tendency to tumble upon entering the target, and only #4 made a straight path through the target; the remainder tumbled and veered off course upon striking the gel. Point #1 took a nosedive and stopped at the base of the target. Point #2 pulled the arrow upwards out the top of the target, and detached as it exited. Point #3 made a diagonal slash through the gel, Point #5 detached within a few centimeters of entering the target, doubling back and becoming lodged (Figure 19).
Figure 18. Point #1 lodged in gel after the arrow was removed. Note the jagged, triangular shock cavity.
Figure 19. Point #5 after detaching and doubling back into the target.
CONCLUSIONS

Given the results of this experiment, it is apparent that the predictions made before the experiment was conducted were supported. Lithic points did indeed require a decent amount of training, but are very feasible and relatively cost effective to create once the learning curve is conquered. Since the quality of the material does make a noteworthy difference in the time invested, it is reasonable to assume that workers sought out the best material available. While organic points take relatively less skill to create and curate, much more time is invested in their manufacture.

In terms of performance, I find it reasonable to conclude that lithic points are best suited for medium and large game, because their wide, slicing cross-section allows the best chance of damaging arteries and vital organs. The quality of the stone did not demonstrate major differences in effectiveness. The distal phalanx points are also well suited for medium and large animals. They did create a noteworthy amount of damage, due to their tendency of tumbling inside the target; more so than any other point type examined. This is likely due to their unusual cross-section. In theory, this tumbling could deliver lacerations to vital organs and arteries, which is required for harvesting medium and large animals. While antler tine points offer superior penetration compared to stone and phalanges, the limited amount of internal damage makes them better suited for small and medium game.
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