

English Longbow Testing

against various armor
circa 1400



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Thesis

Throughout all my research on archery and armour, one detail seems to vary from expert to expert. This detail is the effectiveness of armour against archery. From one source to another, the conclusions (almost always stated as fact) are wildly different. For example, a website by the BBC states that:

“In tests against a steel breastplate, a bodkin-tipped arrow would dent the armour at 260ft, puncture it at 98ft, and penetrate right through plate and underlying doublet coat to the flesh at 65ft.” (Channel 4)

Although a seemingly trustworthy source, there is no detail given about the elements used. Another source states;

“an arrowhead, on the other hand, would only need to deliver 120 Joules to pierce the mail and padding underneath. An archer would find this difficult” (Williams)

Dr Williams very clearly details all his methods and elements but fails to consider that mail is flexible and could still kill a person without penetration. This mass weapon effect has never been considered in any testing that I have come across.

These type of inconsistencies have been the fuel for debate for as long as I have been in the research communities for archery and armour. During these debates, I have always had my own opinion but never felt qualified to interject since I could not back it up. Unfortunately, most people in these debates are stating opinion or quoting some statement by some expert that was stating an opinion. The result is that the same old conversation repeats itself over and over with no outcome. The desire to enter this debate and have facts that I could rely upon was the inspiration to conduct my own tests. The purpose of this research is to determine the effect various medieval arrows have on various medieval armour types. The time period that I tested is around 1400, the time of the English longbow.

Procedure

The National Institute of Justice (NIJ) has developed a procedure for testing modern body armor. This test is unique in the fact that it not only tests for projectile penetration but also for body deformation. The understanding is that just stopping the bullet does not ensure survival of the wearer of the armor. The energy transferred to the body and the area that it is spread over is essential to the effect the projectile has on the body. The procedure for testing deformation is using a backing material with a memory. The NIJ ballistics test specifies the use of a box of Roma Plastilian #1 clay. (Figure 1) The clay is calibrated by drop testing to a specified resistance. The testing standard threshold is 1.7" of clay deformation for the armor to pass (NIJ 0101.04). The penetration threshold is much smaller though. The NIJ stab test indicate a 0.28" max to pass (JII 0115.00). The standard assumed in this test is that the wearer sustaining a wound less than 1.7" of deformation who is brought to the hospital will survive and, as they state in the forward, "The penetration limit was determined through research indicating that internal injuries to organs would be extremely unlikely at 7mm (0.28 in)". In the 1400s this standard would have been much less. Without modern medical treatment many wounds we consider treatable would become fatal. Without period evidence, however, I had to use the only documented number I could get for penetration and deformation thresholds. Although the modern test only uses the armor itself, I used the entire assembly of armor and padding to make up the test. My assumption is that the clay in each of my test is the flesh of the wearer. My hope is that by using this methodology, I will learn more about how armor protects the body.



Figure 1. Body armor testing

Longbow

The common military use of the longbow comes of age in the time of Edward II and is used to great effect against the French between the 1340s and the 1420s. (Hardy, p. 41) There are only 5 sources of existing medieval longbows:

The Spencer Bow

Dating to the 14th or 15th century, this was the model that I based my experiments on. The bow is 79" long with a draw weight of 100 lbs. It is made of English yew wood and had horn nocks on the ends to hold the string. (Hardy, p. 54)

The Mendlesham bow

This 53 inch bow was found in Suffolk England. It dates to approximately 1540, had a draw weight of 80 lbs. (Keiser)

The Hedgeley Moor Bow

Presented to Alnwick Castle around 1464. It is 65.5 inches long with a draw weight of 50 lbs. (Keiser)

The Flodden Bow

A 90 lbs bow claimed to date to 1513 where it was used in the Battle of Flodden. "a landmark in the history of archery, as the last battle on English soil to be fought with the longbow as the principal weapon." (Keiser)

The last source is the H.M.S. Mary Rose. A ship in the English fleet that sank off Portsmouth on Sunday July 19th 1545. There were 167 bows recovered from this ship. They range in size from 75 inches to 80 inches and with a draw weight average of 100 lbs. (Wikipedia)

"All of these bows are similar. They are nearly six feet long; made of wood; shaped in order to use both the center and sap wood; are symmetrically tapered; and appear to have a very stiff

draw weight.” (Keiser)

All the bow are also self bows, which means that they were made from a single stave of wood. (Keiser) They also were lacking any arrow shelf so that the arrow would have been shot off the hand.

Tested Bow

The Bow used was a 75 lb @ 28” Oregon yew self longbow. It has a 72” string length and horn knocks. (Figure 3) The simple leather grip requires the arrows to be shot off the hand. (Figure 4)



Figure 3. Oregon self yew longbow



Figure 4. Oregon self yew longbow detail

Arrows

“Few sources agree to its [medieval arrows] length, estimates range from 27 to 36 inches” (Kaiser)

The sole surviving medieval arrow is in the catalogue for the London Museum. The card for the piece reads;

“This is a typical medieval war head, with small barbs to prevent the arrow from being easily withdrawn (type 16) it seems likely that the wood is either ash or birch” (Kaiser)

This arrow, referred to as the Chapter House Arrow, was 30.5” and weighed in at 1.5 ounces (720 grains). It is fletched with feathers and is self nocked (Kaiser).

The arrows found in the Mary Rose were not as intact but were of a much heavier shaft. The weight of these arrows ranged from 1000 grains to 1500 grains. Although most of the arrow heads were gone, the remaining indicate that they were of type 16 (as cataloged in the London Museum “commonest by far”), and were self nocked. There are also glue marks left from where the fletching were attached and tied on (Mary Rose). One of the type 16 arrow heads in the London museum was analyzed to determine the metallurgic makeup. This arrow head was .35% Carbon steel with a mild steel shank (Hardy, 229).

“It is clear that the medieval arrowsmith was able to design and manufacture highly sophisticated arrowheads suitable for the attach of both horse and man” (Hardy 229)



Figure 5. Arrows

Tested Arrows

I chose to test 4 different arrowheads for this project. I wanted to get a broad perspective of the various designs and how they worked (Figure 5). The 4 heads that I chose were the type 7 bodkin (a long four sided needle), type 8 bodkin (a short four sided pyramid), type 13 broadhead (wide hunting arrow head with barbs), and the type 16 broadhead (curved back barbed head) (Figure 7). These four were all attached to 30" , 0.4" diameter ash shafts. The shafts were cut for self nocks and tied with lined thread for reinforcement. The fletching are grey goose, glued on and tied with linen thread (Figure 6). The final weights of the arrows were:

Type 7 (needle bodkin)

= 905 grains

Type 8 (short bodkin)

= 1150 grains

Type 13 (wide broadhead)

= 950 grains

Type 16 (curved broadhead)

= 935 grains



Figure 6. Arrows fletching and self nocks

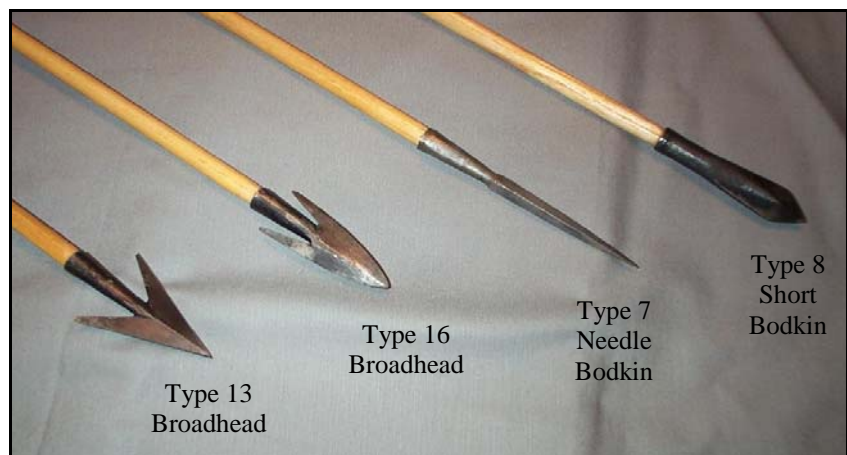


Figure 7. Arrows heads

Calculations

The problem of simulating a period war longbow is that they were much more powerful than anything we use today for target shooting or even hunting. In order to simulate the impact of a 110 lb longbow I needed to determine what the momentum was at full distance. This would be the slowest it would hit but, from a tactical angle, would be the most likely time archery would have been used. (Hardy, p. 82) The bow that I had access to was a 75 lb longbow. The calculations below were for the sole purpose of determining the distance a 75 lb longbow needs to be shot in order for the momentum to equal a 110 lb longbow at range. (see longbow section for description). I also assumed a period average for arrow weight. (see arrow section for description). The arrows that were actually used were averaged and that is my tested weight for the final calculations. The formula I used was primarily from an article reproduced online from a Physics Review in 1995, “The Physics of Medieval Archery”. (Rees)

110 lb Longbow

Historic Values and Assumptions

(gravity) $g = 9.8 \text{ m/s}^2$

(bow weight) $f = 110 \text{ lbs} = 489.5 \text{ N}$

(draw length) $x = 28'' = .7112\text{m}$

(efficiency) $e = .9$

(mass arrow) $m = 1000 \text{ grains} = .065 \text{ kg}$

(mass bow) $m_b = 1 \text{ kg}$

(kinetic energies) $k = .04$

(constant for arrow) $c = 10^{-4}$

(time of impact) = $\Delta_t = 0.1 \text{ sec}$

Calculations

Calculation for (initial velocity) $v_i = \sqrt{\frac{efx}{(m + km_b)}}$

$$v_i = \mathbf{54.63 \text{ m/s}}$$

Calculation for (max distance) $d = \frac{v^2}{g} \left(1 + \frac{cv^2}{mg} \right)^{-0.74}$

$$\mathbf{d = 229.16 \text{ m (251 yds)}}$$

Calculation for (final velocity y) $v_y = v \sin 45$

$$v_y = \mathbf{38.63 \text{ m/s}}$$

Calculation for (flight time) $t = \frac{2v_y}{g}$

$$\mathbf{t = 7.88 \text{ sec}}$$

Calculation for (final velocity x) $v_x = \frac{mv_o}{ctv_o + m}$

$$v_x = \mathbf{27.535 \text{ m/s}}$$

Calculation for (final velocity) $v_f = \sqrt{v_x^2 + v_y^2}$

$$v_f = \mathbf{47.44 \text{ m/s}}$$

Calculation for (momentum) $M = mv_f$

$$\mathbf{\underline{M = 3.08 \text{ kgm/s}}}$$

Calculation for (kinetic energy) $KE = \frac{1}{2}mv^2$

$$\mathbf{KE = 73.1 \text{ J}}$$

75 lb Longbow calculations

Actual tested values (*where different from historic assumptions*)

(bow weight) $f = 75 \text{ lbs} = 333.75 \text{ N}$

(mass arrow) $m = 985 \text{ grains} = .0638 \text{ kg}$

Calculation for (initial velocity) $v_i = \sqrt{\frac{efx}{(m + km_b)}}$

$v_i = \mathbf{48.19 \text{ m/s}}$

Calculation for (momentum) $M = mv_f$

$M = 3.08 \text{ kgm/s}$

Calculation for (kinetic energy) $KE = \frac{1}{2}mv^2$

$KE = 74.1 \text{ J}$

From the calculations above, The 110 lb longbow at full 250 yd range will equal the 75 lb longbow in momentum at point blank range. I used 10 yards for safety reasons to simulate point blank range (Figure 2).



Figure 2. Testing setup

Jack Coat Test

The Jack coat was an armour primarily made up of layered linen topped with deerskin. This form of defense would have been very common and was considered the “most serviceable defense in the fifteenth century” (Ffoulkes, p. 87). Although seemingly less protective, this would have been easy to construct and would have been the most inexpensive armor of my tests. The period construction would have been between 15 and 30 layers of linen stitched to one layer of deerskin on top (Ffoulkes, p. 87). I used 15 layers of linen stitched to 1 layer of deer skin on top. See figures 8 through 18 and table 1 for testing results.



Figure 8. Needle Bodkin



Figure 9. Needle Bodkin Cut



Figure 10. Body Deformation



Figure 11. Short Bodkin



Figure 12. Body Deformation



Figure 13. Broadhead



Figure 14. Broadhead Cut



Figure 15. Body Deformation



Figure 16. Type 16 Broadhead



Figure 17. Type 16 Broadhead Cut



Figure 18. Body Deformation

Table 1. Jack Coat					
Arrow Style	Armor Label	Test #1		Test #2	
		Body Penetration	Deformation	Body Penetration	Deformation
Needle Bodkin	A	3.7"	0"	3.7"	0"
Short Bodkin	D	0"	1.4"	0"	1.3"
Broadhead	B	1.3"	.8"	1.3"	.75"
Type 16 Broadhead	C	3.8"	0"	3.8"	0"

Indicates probable death - based on National Institute of Justice body armor testing for certification. 1.7" threshold for deformation (NIJ 0101.04) & 0.28" threshold for cutting penetration. (NIJ 0115.00)

Butted Maille Test

Although no butted maille armor has ever been found, the debate as to it's existence continues. I included this armor test, not because I believe that it did exist, but to shed some light on how it would have performed. I used 18 gauge mild steel wire with a inside diameter of 5/16" round wire butted together. The understanding today is that most maille in period was iron and not steel. Dr. Smith tested 16 rings from various maille garments of known sources. Of these, 3 of them contained enough carbon to be considered steel (Smith). The padding that was used was 2 layers of linen stuffed with 1" of cotton batting (Fflulkes p.88). See figures 19 through 29 and table 2 for testing results.



Figure 19. Needle Bodkin

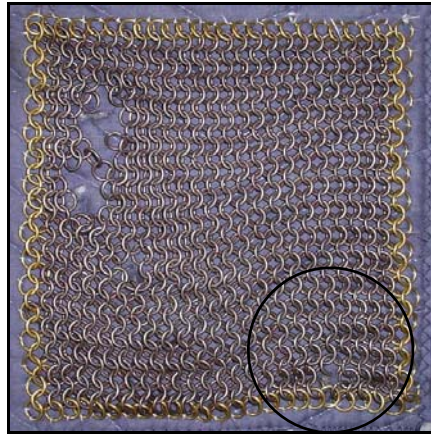


Figure 20. Needle Bodkin Cut



Figure 21. Body Deformation



Figure 22. Short Bodkin



Figure 23. Body Deformation



Figure 24. Broadhead

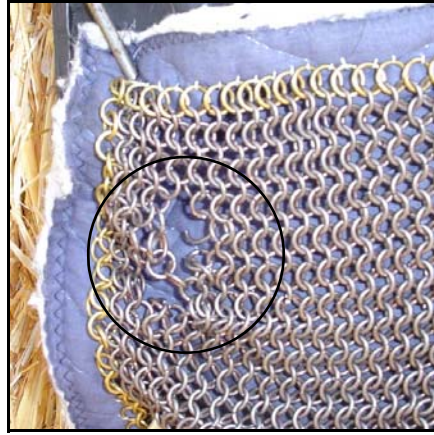


Figure 25. Broadhead Cut



Figure 26. Body Deformation



Figure 27. Type 16 Broadhead

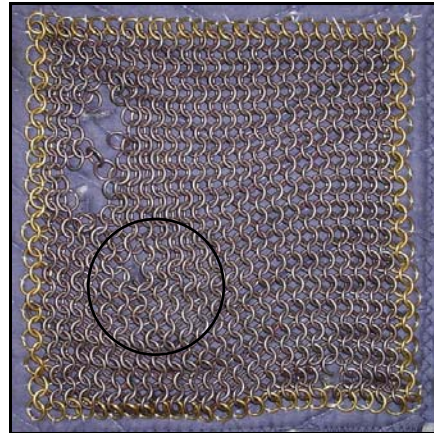


Figure 28. Type 16 Broadhead Cut



Figure 29. Body Deformation

Table 2. Butted Maille					
		Test #1		Test #2	
Arrow Style	Armor Label	Body Penetration	Deformation	Body Penetration	Deformation
Needle Bodkin	E	4.2"	0"	-	-
Short Bodkin	E	1.7"*	0"	-	-
Broadhead	E	1.7"*	0"	-	-
Type 16 Broadhead	E	2.8"	0"	-	-

Indicates probable death - based on National Institute of Justice body armor testing for certification. 1.7" threshold for deformation (NIJ 0101.04) & 0.28" threshold for cutting penetration. (NIJ 0115.00)

* Indicates rings embedded into skin

Riveted Maille (average quality) Test

This was the first of two tests on riveted maille. I wanted to see if the quality and or material of the maille would change the testing outcome. This maille is made up of 18 gauge iron wire with a 5/16" inside diameter, with a 0.79 cm outside diameter. The range of ring diameters from the Battle of Wisby were from 0.4cm to 1.7cm (Thordeman, p. 111). These rings are slightly flattened with wedge rivets, much like the rings of the A9 mantel (Schmid). The patch was padded with 2 layers of quilted linen with 1" of cotton batting (Ffoulkes, p. 88). See figures 30 through 38 and table 3 for testing results.



Figure 30. Needle Bodkin

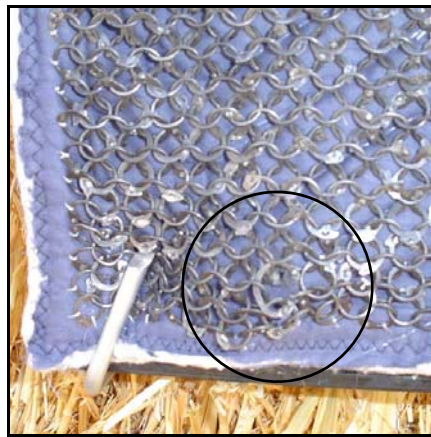


Figure 31. Needle Bodkin Cut



Figure 32. Body Deformation



Figure 33. Short Bodkin

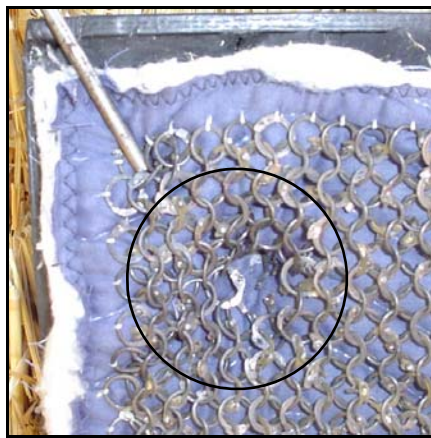


Figure 34. Short Bodkin Cut



Figure 35. Body Deformation



Figure 36. Broadhead

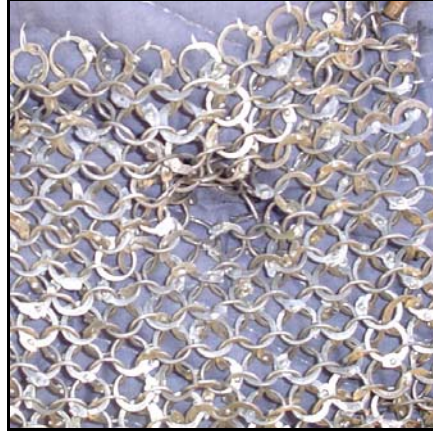


Figure 37. Broadhead Cut



Figure 38. Body Deformation

Table 3. Riveted Maille (average quality)					
Arrow Style	Armor Label	Test #1		Test #2	
		Body Penetration	Deformation	Body Penetration	Deformation
Needle Bodkin	F	2.8"	0"	4.7"	0"
Short Bodkin	G	1.3"*	1.2"	1.4"*	1.3"
Broadhead	H	1.8"*	0"	1.8"*	0"

Indicates probable death - based on National Institute of Justice body armor testing for certification. 1.7" threshold for deformation (NIJ 0101.04) & 0.28" threshold for cutting penetration. (NIJ 01115.00)

* indicates rings embedded into skin

Riveted Maille (high quality) Test

The second of the maille tests was a higher quality of material, craftsmanship and design. This maille is made up of 18 gauge steel wire with a 5/16" inside diameter. As stated in the butted maille test, Dr Smith determined that some period maille garments were made of steel (Smith). The rings were heavily flattened with a clockwise rotation. Flattening the entire ring was common to reduce the overall weight and force the metal into the strong axis (Schmid, p. 13, image #25). Steel wedge shaped rivet were used to fasten each ring together. European maille was most commonly riveted with a wedge rivet made out of iron or Latten (Schmid, p. 13). Like all previous maille tests, this patch was padded with 2 layers of quilted linen stuffed with 1" cotton batting (Ffoulkes, p. 88). See figures 39 through 48 and table 4 for testing results.



Figure 39. Needle Bodkin

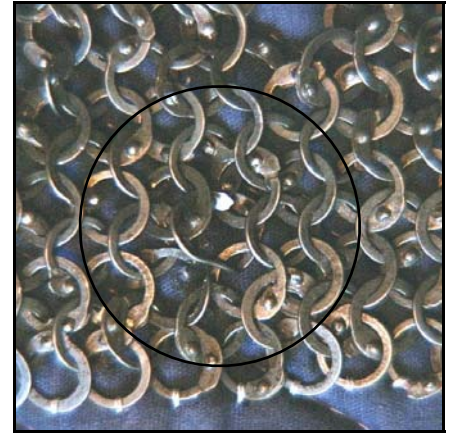


Figure 40. Needle Bodkin Cut

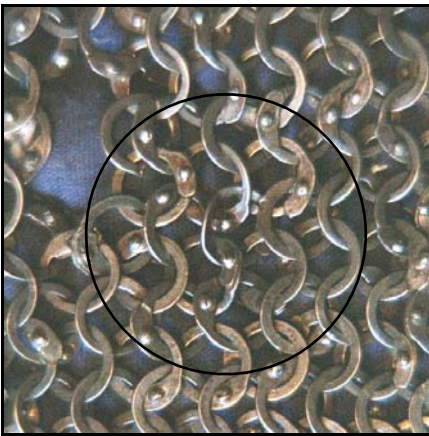


Figure 41. Short Bodkin



Figure 42. Body Deformation



Figure 43. Broadhead

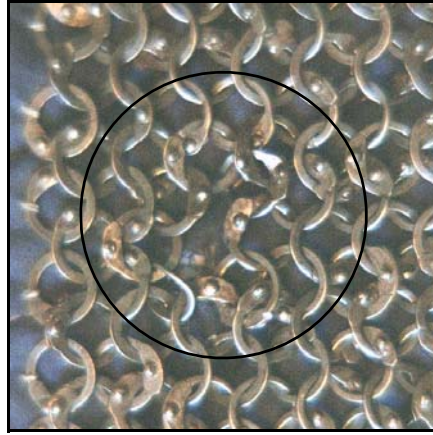


Figure 44. Broadhead Cut



Figure 45. Body Deformation



Figure 46. Type 16 Broadhead

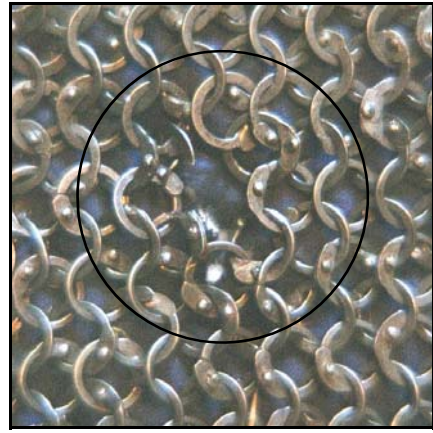


Figure 47. Type 16 Broadhead Cut



Figure 48. Body Deformation

Table 4. Riveted Maille (high quality)					
		Test #1		Test #2	
Arrow Style	Armor Label	Body Penetration	Deformation	Body Penetration	Deformation
Needle Bodkin	I	2.8"	1.2"	-	-
Short Bodkin	I	0"	1.8"	-	-
Broadhead	I	1.3"	1"	-	-
Type 16 Broadhead	I	3"	0"	2.8"	0"

Indicates probable death - based on National Institute of Justice body armor testing for certification. 1.7" threshold for deformation (NIJ 0101.04) & 0.28" threshold for cutting penetration. (NIJ 0115.00)

Coat of Plates Test

In the battle of Wisby excavation (1361) the majority of the body armour was coat of plates (Thordenman, p. 285). These coats were made of varying plate sizes riveted to a leather outer coat. The find that most closely matches the test patch I made was Armour #24 (Thordenman, p.386). The plate sizes are between 1.5” and 4”. I used 3” square plates to simulate the #24 coat. Covered with 1/16” thick leather and padded with 8 layers of linen. Ffoulkes refers to a steel coat padded with 9.25 yards of linen or 3 layers for an average body (Ffoulkes, p. 50). Other padding details refer to linen stuffed with cotton, like in the maille tests. I decided to average the two to make the 8 layer arming coat for under the plates. See figures 49 through 60 and table 5 for testing results.



Figure 49. Needle Bodkin

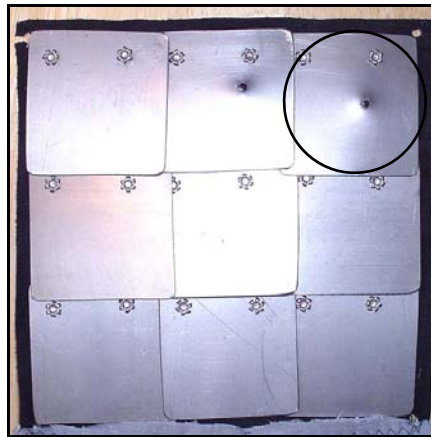


Figure 50. Needle Bodkin Cut (backside)



Figure 51. Body Deformation



Figure 52. Short Bodkin

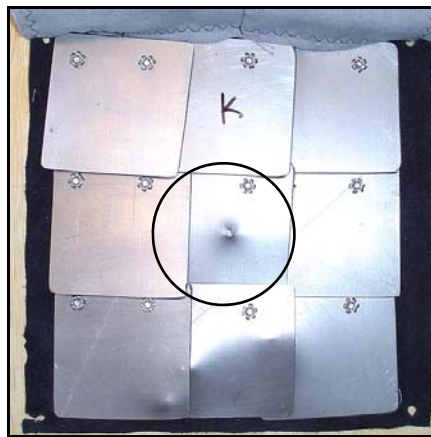


Figure 53. Short Bodkin Cut (backside)



Figure 54. Body Deformation

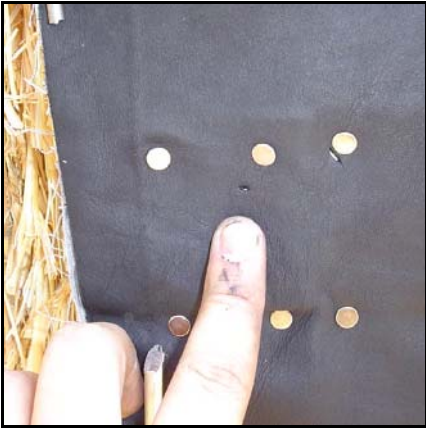


Figure 55. Broadhead

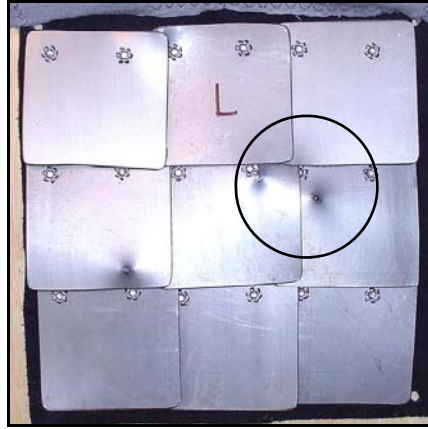
Figure 56. Broadhead Cut
(backside)

Figure 57. Body Deformation



Figure 58. Type 16 Broadhead

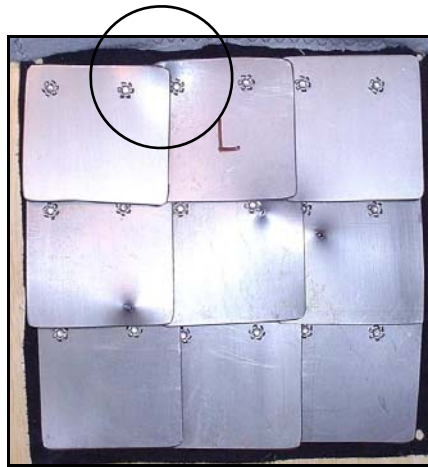
Figure 59. Type 16 Broadhead Cut
(backside)

Figure 60. Body Deformation

Table 5. Coat of Plates					
Arrow Style	Armor Label	Test #1		Test #2	
		Body Penetration	Deformation	Body Penetration	Deformation
Needle Bodkin	J	0.3"	0.1"	0.4"	0.1"
Short Bodkin	K	0"	0.4"	0"	0.3"
Broadhead	L	0"	0.2"	0"	0.2"
Type 16 Broadhead	L	0"	0.4"	0"	0.3"

Indicates probable death - based on National Institute of Justice body armor testing for certification. 1.7" threshold for deformation (NIJ 0101.04) & 0.28" threshold for cutting penetration. (NIJ 0115.00)

Plate Armor Test

Like the coat of plates, plate armour was designed to increase the protective qualities against such weapons as the longbow (Pfaffenbichler, p. 8). The most important detail of this test is the thickness of the metal. Measurements were done by Robert Hardy in the Tower of London on many different helmets and breastplates and the minimum thickness was 1.2 mm thick and the maximum was 4.57 mm (Hardy, p. 233). I decided to test the minimum thickness and move up if need be to determine the penetration threshold of my longbow test. The padding that I used under the plate was 3 layers of quilted linen. This thickness is equivalent to a arming coat made for Henry VIII which was made up of 9 yards of Cheshire cotton (Ffoulkes, p. 92). See figures 61 through 71 and table 6 for testing results.



Figure 61. Needle Bodkin



Figure 62. Needle Bodkin Cut

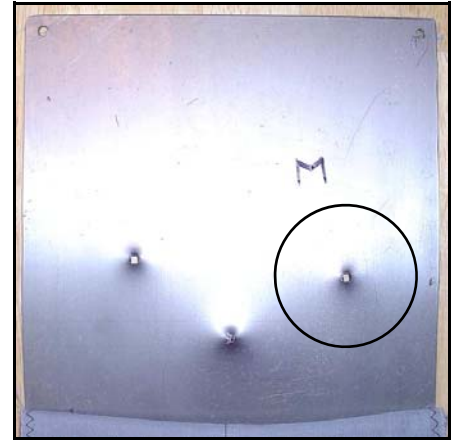


Figure 63. Needle Bodkin Cut (backside)



Figure 64. Short Bodkin

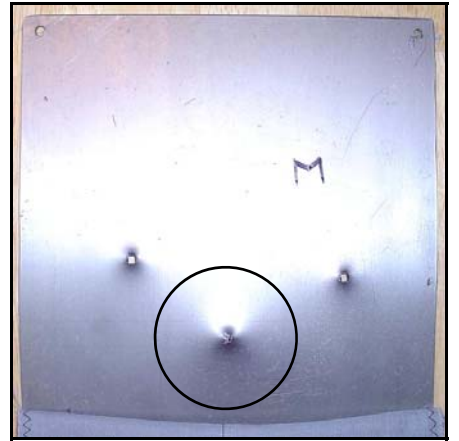


Figure 65. Short Bodkin Cut (backside)



Figure 66. Broadhead



Figure 67. Broadhead Cut (backside)



Figure 68. Body Deformation



Figure 69. Type 16 Broadhead



Figure 70. Type 16 Broadhead Cut (backside)



Figure 71. Body Deformation

Table 6. Plate					
Arrow Style	Armor Label	Test #1		Test #2	
		Body Penetration	Deformation	Body Penetration	Deformation
Needle Bodkin	M	0.5"	0"	0.5"	0"
Short Bodkin	M	0"	0.1"	0"	0.1"
Broadhead	N	0.25"	0"	0.2"	0"
Type 16 Broadhead	N	0"	0.1"	0"	0.1"

Indicates probable death - based on National Institute of Justice body armor testing for certification. 1.7" threshold for deformation (NIJ 0101.04) & 0.28" threshold for cutting penetration. (NIJ 0115.00)

Conclusions

The question that needed answering is;

Can an average longbow, (average draw weight and average arrow weight) at range, defeat the armour that I tested.

My goal was not to determine if there is a period longbow that can defeat all armour and to prove that plate is not proof. My soul intent was to further understand the effect the archery community in an army had in battle from a personal body armour point of view.

Jack Coat

This was the first test that was preformed and was, by far, the most surprising. Although defeated by three out of the four arrow types, the effectiveness of slowing down arrows was great. The deerskin rolled into the penetration in the needle bodkin tests and acted like a break. The linen padding was enough to distribute the force of the short bodkin and keep the deformation under the fatal threshold. The armour that I tested was the thinnest documented jack I could find. The thickest was almost twice as thick, and in my opinion, would have been enough to stop the needle bodkin as well as the short bodkin that the thinner armour stopped. The bladed arrows on the other hand were much more in line with the outcome that I expected. The cutting force against the deerskin and linen was very efficient and ended in a 3.8" penetration. The jack coat at it thickest would have been an effective armour on the battlefield, although I expect very hot and resistant to movement.

Butted Maille

Many people believe that butted maille existed in period as an armour type. I feel that this test shows the main reason why it was not used. The butted maille was no match for any of the arrows that were shot at it. Even the short bodkin and large broadhead had 1.7" of penetration. The biggest reason that I feel that this armour type was not used was the fact that either the penetration was excessively deep or only slightly deep but broken rings were pushed into the flesh. Not only would this armour not stop arrows, but it would introduce more dan-

gers. In the case of the barbed arrows, the armour only impeded the arrow from being withdrawn. In my test shots all the barbed arrows needed to be pulled through, not pulled out. The best summary that I can give on butted maille is that it would be better to be wearing nothing rather than butted maille.

Riveted Maille (average quality)

This test patch, albeit riveted, was not much better than the butted test. The rings were inconsistent in craft and the integrity of the metal around the rivet was questionable on average. Although the penetration depths were slightly shallower, every arrow was fatal. I only had two test patches so I decided to only test the arrows that were of lesser potential penetration and save the type 16 arrow of the high quality test. The needle bodkin, or as it is referred at times, the maille bodkin, popped open one link and pushed in to a depth of 2.8". With such a small area of armour contact, this arrow would be difficult to stop with any period maille. The short bodkin did not punch all the way through but instead pushed rings through the padding and into the flesh, breaking the skin to a depth of 1.3" and also leaving a dent very close to the fatal threshold. The Broadhead cut many rings but not enough to get the barbs past the rings. Although not full penetration, the depth was 1.8" and it too sent broken rings into the flesh. Riveted maille of this quality was not much more effective than butted.

Riveted Maille (high quality)

The last maille test was made of rings of high quality metal and craftsmanship. The metal around the rivets was consistent and solid. The needle bodkin performed exactly like the previous maille, breaking one link and penetration 2.8". The short bodkin however, did not penetrate the metal and bounced off. This seems to be a good sign, but the deformation was 1.8" which is over the fatal threshold. The broadhead arrow once again did not get the barbs past the maille but in this case, did not introduce rings into the flesh. The penetration was 1.3". Finally the type 16 arrow, which is indicated as the most common, cut through the rings and the padding to a depth of 3". This head was very efficient and deadly against this armour and, in my opinion, should take over the title of maille arrowhead from the needle bodkin. Although the needle bodkin penetrated further, the

type 16 arrow would not be able to be removed while the armour was in place and would cause a much larger cut in the body. This high quality maille shows that the craftsmanship of the rivet has a great impact on the penetration of arrows. If the wearer was using thicker padding under the maille, the short bodkin and the broadhead could possibly be rejected safely. No matter how thick the padding, except the very impractical thickness, the type 16 and the needle bodkin arrows would not be stopped by maille armour.

Coat of Plates

The small overlapping plates under the leather were a good defense against arrows. Only the needle bodkin penetrated at all and although technically past the threshold, the wound would be very small and, unless hitting a major organ, likely survivable. The other tests did not penetrate but did leave large plate sized deformations. These dents were well within the threshold, but would have had an impact on the wearer. The leather outer layer would also help in oblique angle shots in giving the arrow head a purchase point. This would increase the number of arrows that made full contact. Although protective, the coat of plates would have been an uncomfortable armour to be struck in by a longbow.

Plate

The outcome of this last test came as no surprise. The plate stopped most arrows. The needle bodkin again punched past the threshold but would not create a great risk to the wearer. The padding that was tested seems to be the bare minimum of arming coats. If this layer was increased, I believe that none of the arrows would have touched the skin. There also was very little to no deformation. With a slight change in padding, this armour would be comfortable and very protective against the longbow with any arrowhead.

Compared with other tests

There are only 3 tests that I have read about that seem to get all the parts together to draw any real conclusions. The first is the Dr Williams test (Williams). He tested armour on a laboratory drop tester to determine the amount of energy that was required to penetrate maille. His tested energy levels for archery were 80 Joules,

very close to my 73 Joules. Dr Williams determined that an arrow would not penetrate maille. His maille was made by Erik Schmid and I have no question to it's authenticity (Schmid). The tip he used on the drop tester, however, was a stock pyramidal spike very much like my short bodkin. So when I look at the two tests, I do not disagree with his outcomes. The problem is that he did not measure any deformation caused by the transfer of the arrow's energy. He also did not test other arrow types like the type 16 that we saw penetrate with ease.

The second test is the Hardy test (Hardy, p.234). Robert Hardy was very particular about the arrows and the armour but only tested plate. His conclusions were that the arrows only achieved partial penetration. The only issue is that they were not over any padding material, so that the final body penetration is unknown.

The third test is the Primitive Archer test (Bickerstaffe). The bows in this test were up around 160 lb draw weight and they were testing at point blank range. The energy in the arrows calculated out at 156 Joules. Although the test showed the arrows penetrating a replica breastplate, I can not image this scenario occurring on the battlefield. This was an impressive test but ultimately not very educational.

All in all, the test results that I recorded seem to fit in with the other known tests of archery and armour.

Conclusion

Most soldiers on the battlefield would have been at risk from the longbow. The average archer would have had the tools to wound or kill most armour types. Even with the advent of coat of plates, the archer would have had an impact on an advancing army. Only the most expensive and well made plate armour wearers would have had an advantage. Although even with plate, I only tested the impacts to major protected areas. The joints and gaps would all still be vulnerable being mostly of maille until the 16th century. Without significant metal to withstand the energies of an arrow or excessive padding to spread out the force, arrows of the 1400's would have been deadly.

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