Forcing Cone Alteration and its Effect on Shotgun Pattern Performance©

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Introduction

The evolution of the forcing cone has been an interesting process since the invention of breech loading shotguns in the latter half of the 19th century. Aside from the adoption of more acute angles that function better with modern plastic wads (from 5 ¼ degrees to 2 degrees on most factory barrels), the forcing cone has remained relatively unchanged. In the aftermarket, some have claimed to improve shotgun pattern performance by various alterations to the interior of the shotgun barrel to include the forcing cone. Most often these alterations included high polish, extremely acute angles, or a combination of the forcing cone and bore to form a taper from the chamber to the choke. Ken Eyster developed a system based on observations of the best English guns from the late 19th and early 20th century. The testing described here will determine the effect of the process he re-discovered to improve shotgun pattern performance via forcing cone alteration.

History*

In regard to shotgun chambers and their transition into barrels, the best makers at the end of the 1900's used a similar technique: namely, the chamber ended and the barrel began. There was no transition space. The paper shell opened within the chamber on firing; the internal diameter of the case was similar if not identical to the bore of the barrel. Recall that the wads were felt. The gun makers must have feared the loss of pressure had there been any enlargement of the bore. The transition from the chamber to the barrel was at a sharp right angle.

This was the era of black powder and corrosive priming. Cleaned imperfectly, the barrels pitted. Each year at the end of the season, those who could afford to shoot took their guns to their makers: Purdey, Woodward, Boss, etc. for cleaning. Part of this process included lapping the barrels to remove corrosion. They were careful to maintain sufficient wall thickness to keep the guns in proof, but lapping would tend to increase bore sizes slightly and round edges on forcing cones. The barrels were made originally with this process in mind. The better shots, Ripon, Walsingham, Edward VII, etc. noted that their guns shot better the older they were. They passed this on to the gun makers who must have asked their barrel makers what could cause such a phenomenon. As an aside and when you think about it, this observation didn't help new gun sales.

A few barrel makers discovered that each time they lapped a barrel, they created and enlarged a small radius on the angle between the chamber and the barrel: alas, the precursor to the forcing cone. The two prominent barrel makers (finishers) of the period 1880 to 1910 were William Hill and Harry Aston. To our knowledge, no one wrote about it; neither were there any patents. It was a "trade secret."

This is the phenomenon that Ken Eyster re-discovered almost 100 years later. If one is mindful of that junction between the chamber and the bore, Ken’s data indicated that one can increase the number of pellets delivered to the killing zone by 8%. Others have made exaggerated forcing cones without really knowing what they are doing. Ken's work and that of those few old barrel makers indicate that it doesn't take much to produce much better results.

Description of Test

To test the effect of the radius in a modern barrel, Norbert Hausman of Blaser USA provided Blaser F3 32” barrel. The O/U barrel had 3” chambers, a two degree forcing cone, and chrome lined bore of .732”. The under barrel was used for the testing. The first step was to remove the chrome via the process of honing. Although chrome plating is not known to affect performance, it is difficult to create a good radius from the cone into the bore because of the difference in material as the chrome gives way to the barrel steel in the lapping process. For this reason, the bore was honed out to .735” to eliminate the chrome.

The barrel was then fired ten times from thirty yards. Coverage and efficiency (see definitions) were documented on each of the ten targets, in addition to documenting the percentage of shot in a ten-inch diameter circle. All shots were fired using Winchester AA 1&1/8 oz, #8, Light Target Loads from the same lot number. The forcing cone was then ‘radiused’, using a series of emery cloth, from coarse to fine, from the breech toward the muzzle, moving no further than eight inches from the breech as to not affect actual choke, nor alter conditions in the bore from the previous test shots. When the lapping was completed, the bore was wiped out with a paper towel on a fiberglass rod, and then the ten shots repeated using the same box of cartridges from the first ten shots. No more than 1.5 hours transpired between the first ten shots to the last ten. Temperatures and weather conditions were unchanged throughout the duration of the testing.

Testing Data

Efficiency: The percentage of shot contained in the center 30” circle of the pattern.

10” Core: The percentage of shot contained in the center 10” diameter of the pattern.

Coverage: Coverage is the area of the pattern that contains adequate density to ensure a break or a kill. Unlike Efficiency and Core measurements, Coverage is more subjective and can vary greatly based on the look of the pattern and judgment of the grader .

	Before				After		
Shot #	Coverage	Efficiency (30")	10"		Coverage	Efficiency (30")	10"
1	22.23	95.88	30.09		22.37	94.37	25.9
2	22.68	94.37	29.65		23.94	97.19	29.44
3	22.75	96.5	30.74		22.75	97.8	33.12
4	22.06	97.4	30.7		22.75	97.19	36.15
5	23.37	96.75	26.6		22.9	97.19	35.28
6	22.68	96.32	31.38		22.93	94.8	30.3
7	22.9	89.93	20.3		23.44	96.75	30.74
8	23	95.8	32.5		23.68	95.02	23.37
9	22.5	96.75	28.57		23.125	98.48	36.15
10	22.68	96.32	32.25		22.125	97.62	32.03

		Min	Q1	Median	Mean	Q3	Max	Range
Effic.	Before	89.93	95.82	96.32	95.602	96.6875	97.4	7.47
	After	94.37	95.45	97.19	96.641	97.5125	98.48	4.11
	Difference	+		+	+		+	-
10"	Before	20.3	28.84	30.395	29.278	31.22	32.5	12.2
	After	23.37	29.66	31.385	31.248	34.74	36.15	12.78
	Difference	+		+	+		+	+
Coverage	Before	22.06	22.55	22.68	22.685	22.8625	23.37	1.31
	After	22.125	22.75	22.915	23.001	23.36125	23.94	1.815
	Difference	+		+	+		+	+

Explanation of Results**

Effect on Efficiency of Pattern

From Table 1, the minimum, median, mean and maximum of the two sets of data have been improved from the work on the forcing cone. Overall, this implies that the values of shot percentages within a 30 inch diameter will be greater than before. Also, the overall range of values has dropped by 45% after the work done. This implies that there will be a more consistent, reliable series of shots in the higher percentages than before.

		Min	Q1	Median	Mean	Q3	Max	Range
Efficiency	Before	89.93	95.82	96.32	95.602	96.6875	97.4	7.47
	After	94.37	95.4525	97.19	96.641	97.5125	98.48	4.11
	Difference	+		+	+		+	-

Table 1

This same conclusion can be seen in Figure 1 below. Each segment (the line, the first box, the second box, and the last line) each represent 25% of the shots. The second vertical line represents the median and the dot represents the mean. The range of percentages before the forcing cones were altered is much more spread out than after (from the beginning of the first line to the end of the last). When shooting, the efficiency will tend to hit around the mean and median. From Figure 1, it is easy to see that the efficiency will tend to be around 95.5-96.5% before the work done, whereas after it will be around 96.5-97.25%.

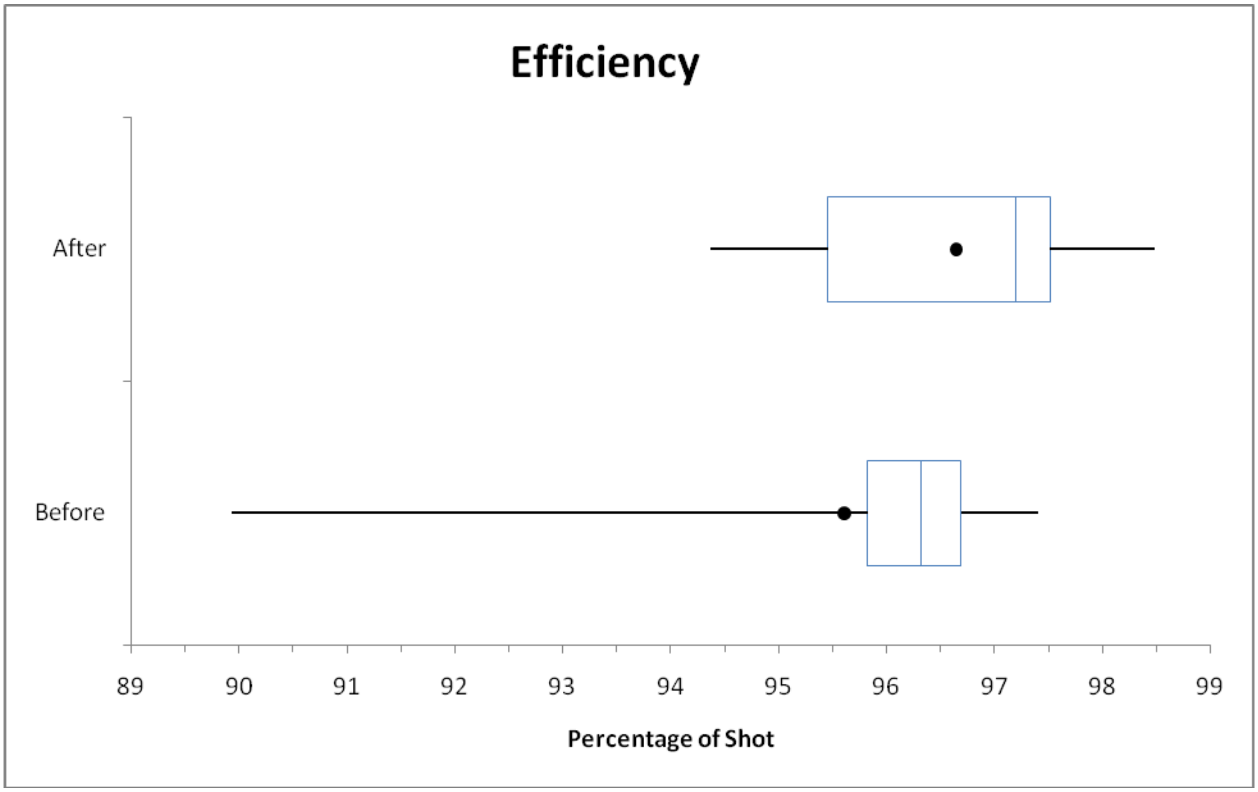

Figure 1

Effect on Percentage of Shot within a 10" Diameter

From Table 2, the minimum, median, mean and maximum of the two sets of data have been improved from the work on the forcing cone, similar to the efficiency. Overall, this implies that the values of shot percentages within a 10 inch diameter will be greater than before. However, the overall range of values has increased after the work done. The range increased by .58%, so the consistency within a 10 inch diameter was not affected significantly as the efficiency.

		Min	Q1	Median	Mean	Q3	Max	Range
10"	**Before**	20.3	28.84	30.395	29.278	31.22	32.5	12.2
	After	23.37	29.655	31.385	31.248	34.74	36.15	12.78
	Difference	+		+	+		+	+

Table 2

From Figure 2 below, the same traits can be seen. It is easy to see that even though the range is about the same, the percentage of shot within a 10 inch diameter is overall higher after the work done to the forcing cones. From Figure 1, the percentage of shot within a 10 inch diameter before work done will tend to be around 29.25-30.5%, whereas after it will be around 31-31.5%. Even though these numbers do not reflect a change as dramatic as in the efficiency, these numbers reflect the center core of the pattern. The difference in the mean reflects a 1.97% increase of shot in the core of the pattern. That equates to an average of nearly ten more shot in the center than before.

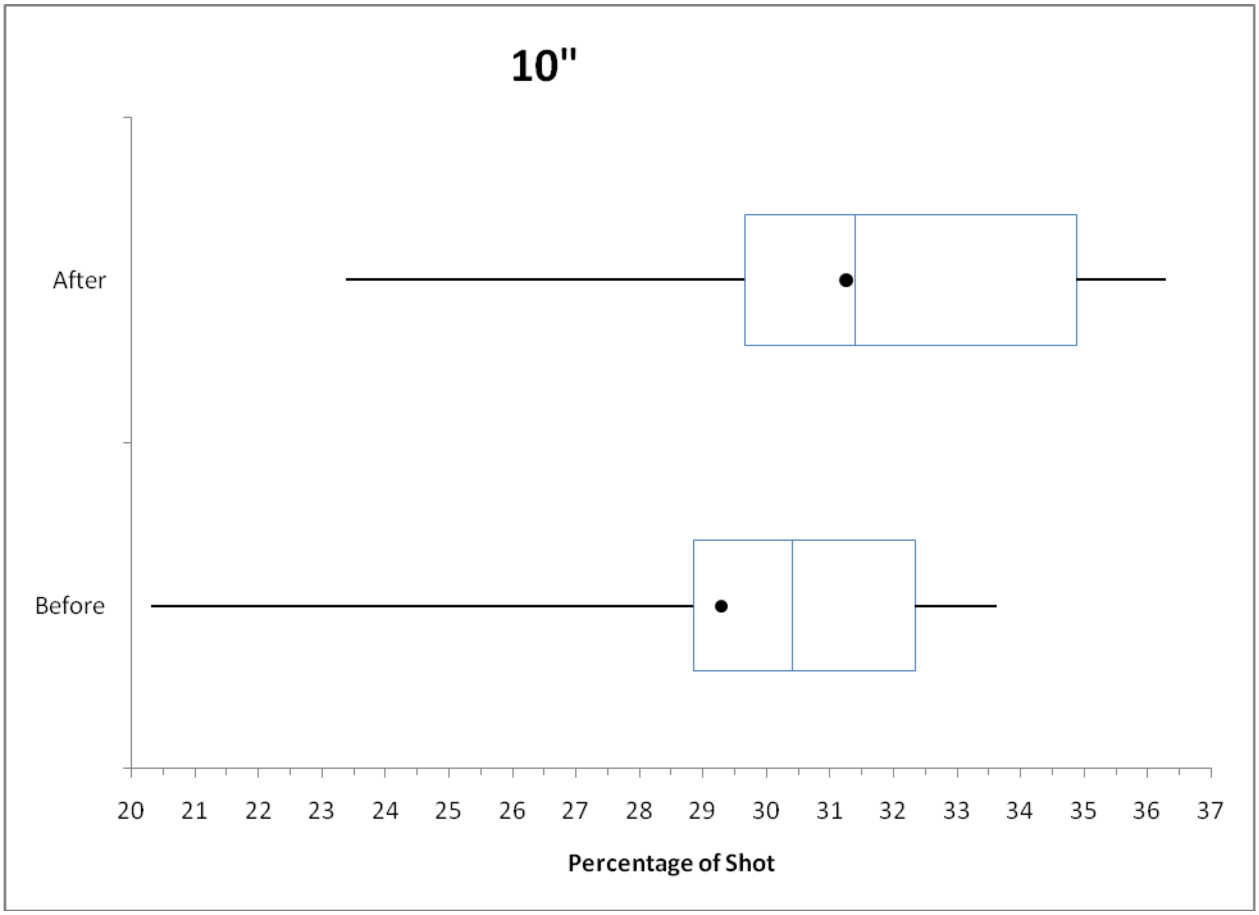

Figure 2

Effect on Coverage

Looking at Table 3, the coverage values for minimum, median, mean and maximum have all increased. The range of coverage sizes has overall increased. The values only indicate a small amount of change ranging from .05 to .5 of an inch. Overall, this implies that the coverage has not been affected greatly. The range of values has increased slightly by approximately .5 inches, implying a very small loss of consistency.

		Min	Q1	Median	Mean	Q3	Max	Range
Coverage	**Before**	22.06	22.545	22.68	22.685	22.8625	23.37	1.31
	After	22.125	22.75	22.915	23.001	23.36125	23.94	1.815
	Difference	+		+	+		+	+

Table 3

From Figure 3, it is seen again that the coverage has not been significantly affected. It is observed more easily than on the table that the range has increased after the work done, however only by approximately a half inch. The coverage will tend to be about 22.7 inches before and 23 inches after.

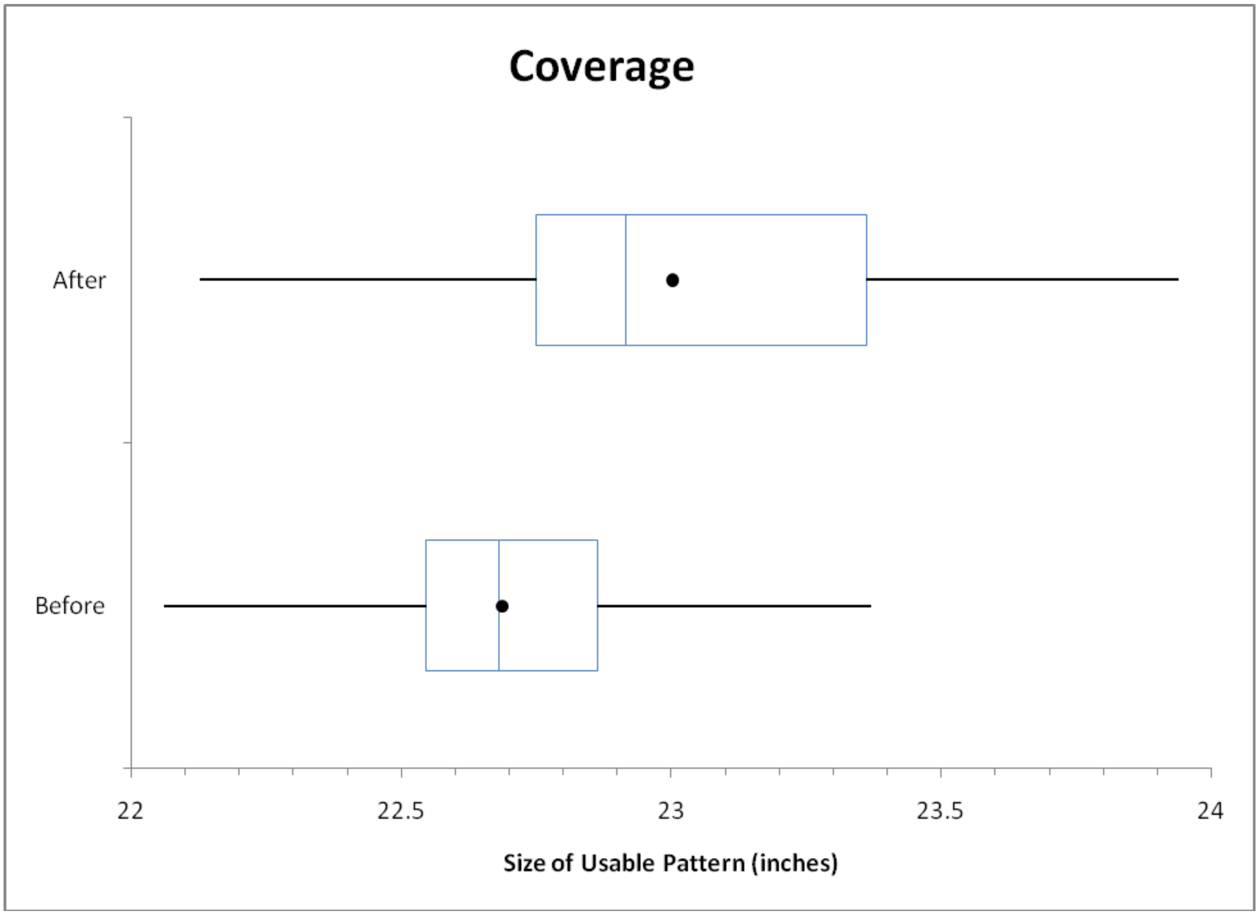

Figure 3

Conclusions:

From the data it's clear to see that the alteration to the forcing cone brought more shot from the outer edges of the pattern into the usable areas. More shot in the center of the pattern increases the probability of strikes on the target and thus better breaks or kills. Bringing more shot into the center of the pattern also increases the maximum effective range of the pattern, as it takes a longer distance for the killing areas of the pattern to deteriorate. It is theorized that the improved transition from chamber to bore allows the shot in the column traverse this short distance of great pressure and reduction in bore diameter with a minimum amount of distortion, maintaining aerodynamic characteristics.

It is interesting that Coverage was not changed in any significant way. Ken often said that you can simply summarize shotgun barrel performance (to the extent that the barrel is responsible for performance) by saying that an efficient pattern is a function of the characteristics of the forcing cone, bore, and choke angle. Coverage, or the size of a killing pattern, is a function of the amount of constriction in the barrel. The fact that the procedures described here did not alter the constriction, and the coverage showed no significant change would support Ken's statement.

In the "History" portion it is stated that Ken's records show as much as an eight percent increase in efficiency. We did not see that here, but in the referred to example we are likely dealing with the combination of an improved forcing cone, honing and lapping of the barrel to create a more optimum bore in size and uniformity, in addition to working in the choke. The work to the choke would include a light lap at a minimum to improve the transition, and could include altering the choke angle and parallel section length if poor performance dictated. In contrast, the test subject used here was a factory new barrel with only the forcing cone work in consideration.

*Thanks to Joe Toot for his input on the history. Ken considered Joe a great friend and much of what he learned from English guns was from the information and examples that Joe provided.

**Thanks to Daniel Eyster for the statistical modeling. My college stats are a little rusty and Daniel was able to suggest and apply models to describe the phenomena we observed.