Comparing Japanese Needle Strength Characteristics

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Abstract

Japanese 1.8x30 mm needles were investigated for strength and breakage susceptibility. Stainless steel needles of 16 ga (1 ½ inch length) from two US manufacturers combined with aluminum and plastic hubs were compared to the Japanese needles by subjecting each to standard test-stand load conditions to compare strength in various loading regimes. A device that simulated pig motion was also used to test breakage characteristics assuming an animal moved during the injection process.

Materials and Methods

Needles from three manufacturers were tested. The testing procedure compared strength characteristics of 1 ½ inch length, 16 ga needles. An aluminum [AL], polypropylene [PL], and Japanese hub [JA] needle-type were tested. All needles were stainless steel. Table 1 outlines the needles and hub combinations that have been tested.

Table 1. Needle and hub assemblies tested.

Size	**Length**	**Hub Material**	**Manufacturer**		
			Allison Medical	*Monoject*	*Japanese*
16 ga	1.5 in	AL		x	
16 ga	1.5 in	PL	x		
1.8 mm	30 mm	JA			x

Tests Conducted

Three basic tests were conducted to quantify strength characteristics of the needles tested. Each is summarized below:

1. *Needle/hub tip bending test*: Each possible needle/hub combination was tested for lateral bending strength as shown in Figure 1. The mounting assembly shown was designed specifically for this project.

2. *Needle/hub full-embedment test*: Needle/hub assemblies were tested for lateral bending strength at the base of each needle/hub joint as shown in Figure 2. This test was conducted to test the breakage strength assuming the needle was fully embedded in the animal and the animal

subsequently moves laterally.

3. *Animal movement testing*: Needle/hub assemblies were tested during a simulated animal movement event after injection. The testing apparatus is shown in Figure 3.

Testing Procedure

Several needle/hub assemblies were obtained from each manufacturer. Separate containers were labeled for each of the possible needle/hub assemblies tested. All assemblies were then placed in each container and mixed. When a loading test was conducted, the appropriate containers were gathered and placed near the testing apparatus. Equally sized "cards" were made indicating each treatment combination for testing and these were placed in a separate container. When testing began, a card was randomly selected and this treatment combination was tested. The card was placed back into the container and the process was repeated until each treatment combination was tested. Five replications were conducted for every test. An ANOVA was conducted to determine the significance of each treatment tested.

Results and Discussion

The results and discussion are included below.

Tip-Bending Test

Table 2 summarizes the results gathered from the tip-bending test using the apparatus shown in Figure 1. The JA hub needles sustained a significantly greater ($p<0.001$) load to failure then either the AL or PL hub needles supplied. The JA hub needles were four times stronger than the PL hub needles and nearly twice as strong as the AL hub needles. Much of this extra strength is due to the extra support provided at the needle/hub joint supplied by the JA needles.

Table 2. Tip-bending test results

needle assembly	Peak Load to Failure (lbs)	S.D. (lbs)
AL hub needles	3.8	0.01
PL hub needles	1.5	0.01
JA hub needles	6.2	0.1

Full-embedment Test

Table 3 summarizes the results gathered from the full-embedment test using the apparatus shown in Figure 2. The AL hub needles sustained a significantly greater ($p<0.001$) load to failure then either the JA or PL hub needles supplied. The AL hub needles were over four times stronger than the PL hub needles and 50 percent stronger than the JA hub needles. This extra strength is due to the superior strength of the AL hub relative to either the PL or JA hub supplied.

Table 3. Full-embedment test results

needle assembly	Peak Load to Failure (lbs)	S.D. (lbs)
AL hub needles	25.0	2.7
PL hub needles	5.9	0.6
JA hub needles	16.5	1.3

Animal Movement Test

Table 4 summarizes the results gathered from the animal movement test using the movement simulator shown in Figure 3. For this loading arrangement, no load data is available; instead failure information is provided. As shown in Table 4, 100 percent of the PL hub needles fractured with movement, leaving the needle and a small portion of the hub embedded in the simulated hide, making removal a relatively easy task. For the AL hub, 100 percent of the needles permanently deformed at the base of the needle/hub joint, leaving the hub unscathed. Reuse of these needles was impossible. For the AL hub needles, the needle deformation was so severe that needles were in danger of breaking in the tissue, although this never was observed. The JA hub assemblies had one hub fracture, one permanently deformed needle, and three needles that could have been reused due to minimal damage.

Table 4. Animal movement test results

	Failure Mode (%)*		
needle assembly	ND	HF	MI
AL hub needles	100	0	0
PL hub needles	0	100	0
JA hub needles	20	20	60

* ND=permanent needle deformation, HF=hub fractured, MI=minimal damage resulting in a reusable assembly.

Conclusions

For tip and full-embedment loadings, significant differences were found between the AL, PL, and JA assemblies. For tip-bending, JA assemblies were far superior to either AL or PL assemblies. For full-embedment testing, the AL assemblies sustained a larger load to failure than either the PL or JA assemblies. However, when the AL assemblies failed, the failure was at the hub/needle joint resulting in a permanently deformed and pinched needle.

The major difference between the needle assemblies tested occurred when animal movement testing was completed, and the following conclusions are based on this loading scheme. PL hubs will tend to permanently sever leaving the needle and a portion of the hub in the tissue, making removal quite easy. AL hub assemblies will transfer all load to the needle resulting in a permanently deformed needle and a very weak joint at the hub/needle interface. With AL hub assemblies there would be a much greater risk of leaving a broken needle in the tissue. With the JA assemblies, there appeared to be a near equal transfer of load between the hub and the needle. This evidently was the result of a stiffened joint between the hub/needle interface. In no case was the needle in danger of severing, and in no case did the hub completely sever. In 60 percent of the cases, the needle could have been reused with very minor straightening.

load position

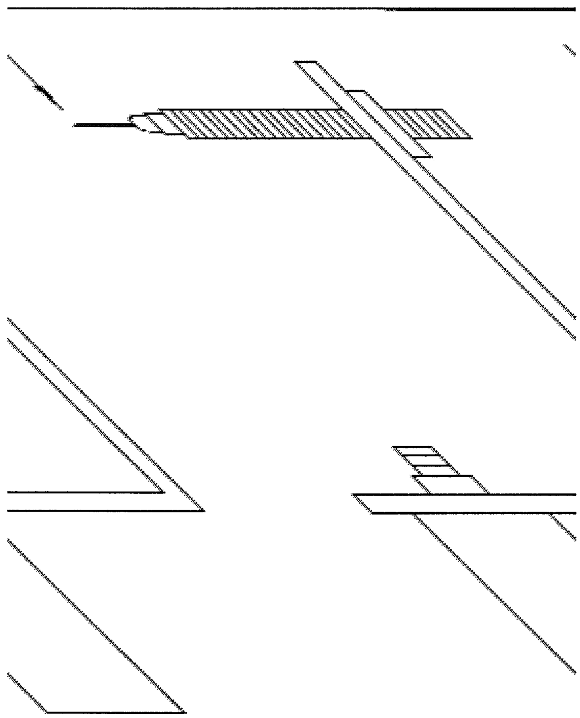


Figure 1. Tip bending test set-up.

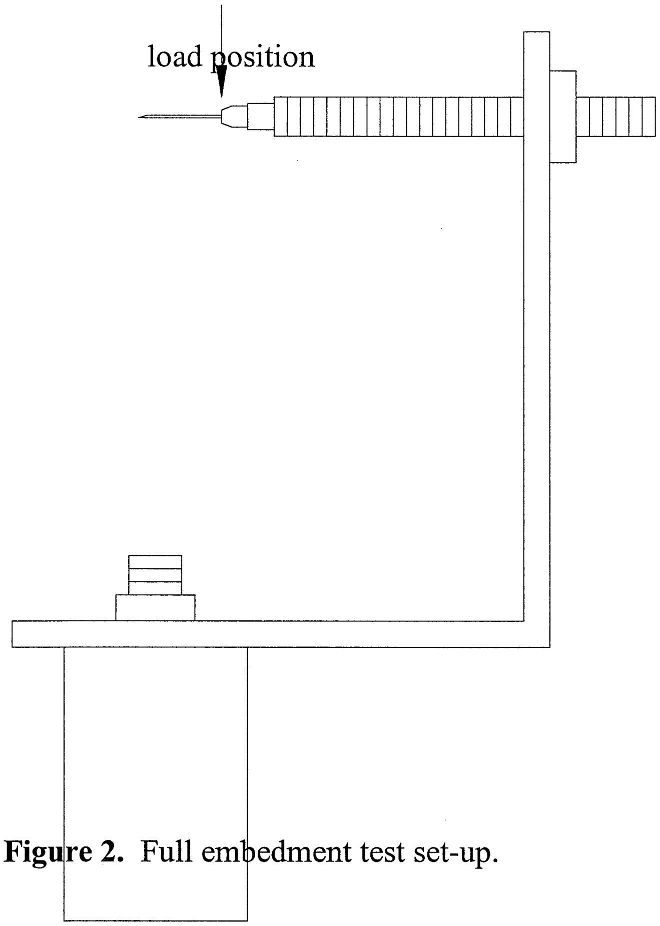
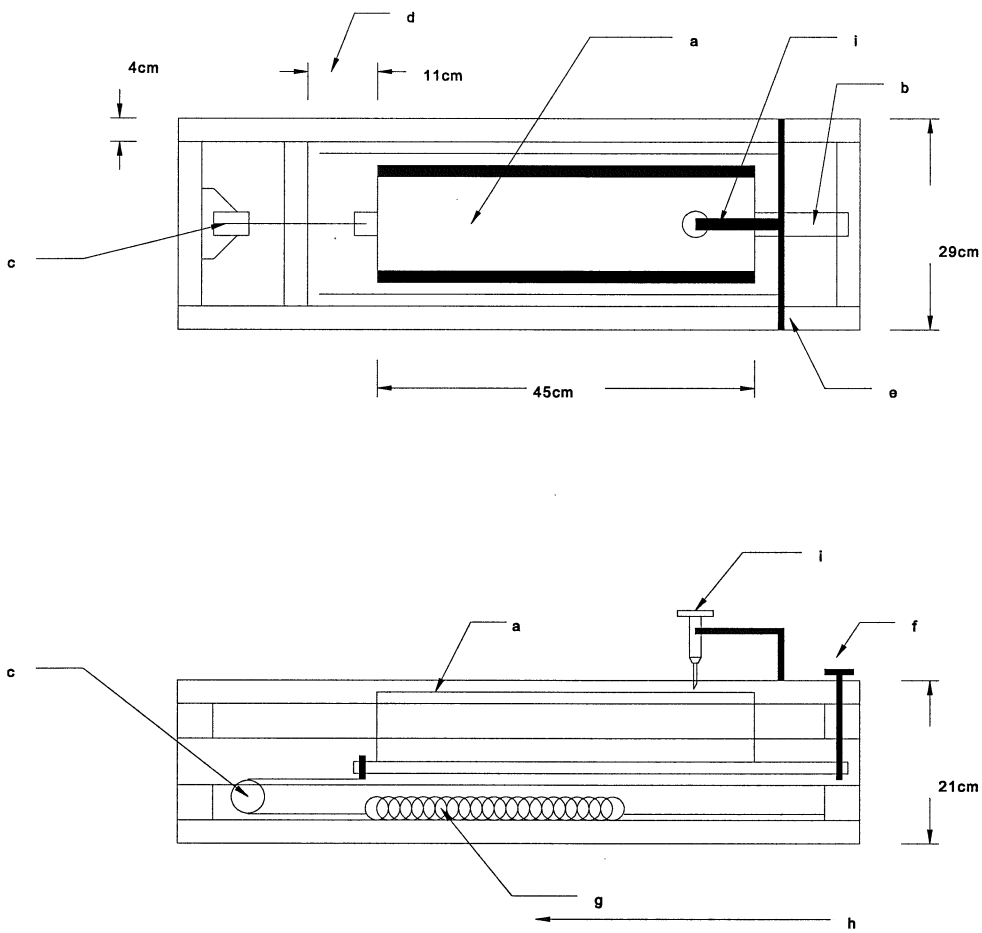


Figure 2. Full embedment test set-up.



a:simulated pig hide
b:assembly latch
c:pulley for adjustable spring
d:maximum assembly movement
e:support stand

f:spring release
g:adjustable spring
h:pig movement direction
i:needle stand (angle adjustable)

Figure 3. Features of the pig movement simulator designed for testing needle/hub strength characteristics under pig movement conditions. Variables tested include lateral movement speed and needle impact angle.