Technical Note

Evaluation and Comparison of Casting Materials on Detailed Three-dimensional Impressions

Adrian Yu[1]
Wade Knaap[2]
Neville Milliken[2]
Paul Bognar[2]

  Abstract: Five casting products used for impression evidence were evaluated and compared to determine the best-performing casting material for making detailed three-dimensional impressions. The focus of the research was on the quality of the casting materials to replicate fine detail. Four of the materials (Mikrosil, AccuTrans, ReproRubber "Thin Pour", and ReproRubber "Medium Body") outperformed the dental stone.

Introduction

When investigating crime scenes, impression evidence is often found at the scene. Impression evidence can be either two-dimensional or three-dimensional and is most often associated with footwear, tire tracks, bite marks, fingerprints, or tool marks. Some crime scenes contain detailed three-dimensional impressions, usually in the form of tool mark impressions or indentations on objects. Detailed three-dimensional impressions may contain information of significant forensic value and can often place a suspect at the crime scene. To preserve this type evidence for investigation, casting is recommended.

  [1]   Markham, Ontario, Canada
  [2]   Toronto Police Service Forensic Identification Services

A few research studies have been conducted in the area of detailed three-dimensional impressions. One research study [1] focused on evaluating and comparing casting materials in different environmental conditions. Sta Seal and Mikrosil were determined to be very effective in a crime scene setting. On the other hand, Sta Seal and Xantopren were determined to be very effective in laboratory conditions. However, the results may have been due to random error, because an inadequate sample size was used in the experiment.

The same research [1] used a grading system to evaluate the results of the cast impressions. The grading system was organized on a scale of 1 to 10 or 1 to 20, but there was not a description of the grading levels that were used. With an undefined grading system, the evaluation was more subjective and opinion-based rather than being an objective test.

Our research focused on the evaluation and comparison of casting materials on detailed three-dimensional impressions. An adequate sample size was used to represent the general population to ensure that the findings were not a result of a random event. The evaluation criteria focused on both class and unique characteristics. We used a clearly defined grading system to reduce subjectivity and ambiguity.

Materials and Methods

Toonie (Canadian two-dollar coin) (Figure 1)

Mikrosil (Kjell Carlsson Innovation, Sundbyberg, Sweden)

AccuTrans (Ultronics Inc., Cuyahoga Falls, Ohio)

Dental Stone (Henry Schein Inc., Melville, New York)

ReproRubber "Thin Pour" (Flexbar Machine Corp., Islandia, New York)

ReproRubber "Medium Body" (Flexbar Machine Corp., Islandia, New York)

Five different casting materials were used in this study. Three of the casting materials (Mikrosil, AccuTrans, and dental stone) are currently used by the Toronto Police Service Forensic Identification Services for crime scene investigations. These three materials were selected because they are most commonly used by forensic investigators. The two remaining products (ReproRubber "Thin Pour" and ReproRubber "Medium Body") have not been previously researched for forensic purposes.

Before comparison of casting materials on a detailed three-dimensional impression was performed, general class and unique characteristics were identified on the "tails" side of the Toonie. These characteristics were used as a reference base for comparing the cast impressions. Four general class characteristics and six unique characteristics were identified for this experiment.

General class characteristics:

1. Diameter of the Toonie - 28 mm

2. Initials "B" and "T" on iceberg

3. Coin contains the words "2 DOLLARS" and "CANADA"

4. Eye, ear, nose, and mouth visible on polar bear

Unique characteristics:
1. Curly scratches located to the top right side of the last "A" in "CANADA"

2. Two to three scratches between the "N" and the second "A" in "CANADA"

3. Single scratch between the "C" and the "A" in "CANADA"

4. Single scratch located at the top left side of the mountains in the picture

5. Single scratch located at the bottom left side of the "D" in "DOLLARS"

6. Single scratch located at the top left side of the "O" in "DOLLARS"

The Toonie was photographed with a scale to record the characteristics that were present at the time of casting. The Toonie was placed on a piece of acetate with the "tails" side of the Toonie facing up. Casting materials were applied onto the Toonie, covering the entire surface. Casting frames were used for low viscosity materials, dental stone, and ReproRubber "Thin Pour". Five casts were made with each material. (Five impressions would ensure that the results were not due to error and that the study represented the general population.) Once hardened, each cast impression was lifted from the object, photographed, documented, bagged, and labelled.

Evaluation

The evaluation process was completed by examining the cast impression using a fingerprint loupe and a light source. This evaluation method used in the study is similar to those methods employed by the Toronto Police Service. Any casting material that could make an impression with a positive identification to the Toonie would be recognized as an appropriate option when dealing with detailed three-dimensional impressions.

The diameter of the Toonie was measured using a ruler, and the remaining class and unique characteristics were observed using the fingerprint loupe. All characteristics were determined to be either present or absent. A final grade was assessed following the set standards from SWGTREAD [2] (Table 1).

Results and Discussion

Cast impressions were examined for class and unique characteristics that were identified on the Toonie. Characteristics were recorded as either present or absent on each cast impression (Table 2).

All five casting impressions created from ReproRubber "Thin Pour" replicated all the class and unique characteristics identified on the Toonie except that the diameter of ReproRubber "Thin Pour" impression #1 measured 27.5 mm, not 28 mm as measured on the Toonie. This could have been a result of the researcher's error, because the acetate may have moved, allowing the Toonie to shift slightly. As a result of the slight shift, the ReproRubber may have seeped in between the Toonie and the acetate and caused the diameter to decrease. Therefore, this discrepancy might be attributed to researcher's error, not

product error. Using this reasoning, all impressions made from ReproRubber "Thin Pour" were considered as "identification" (Figure 2).

All five casting impressions created from ReproRubber "Medium Body" replicated all the class and unique characteristics identified on the Toonie. There were no deviations present in this research. All impressions made from ReproRubber "Medium Body" were considered as an "identification" (Figure 3).

Of the five casting impressions produced by Mikrosil, only impression #5 contained all the class and unique characteristics identified on the Toonie. Impressions #2, #3, and #4 had a diameter measurement of 27 to 27.5 mm instead of 28 mm. This result could be attributed to the research setup and researcher inexperience. The research setup did not require the object to be fastened or glued onto the acetate surface, and the researcher's attempt to apply the thick Mikrosil onto the Toonie may have resulted in shifting the Toonie from its original position. In turn, Mikrosil could have seeped in between the Toonie and the acetate, resulting in an impression with a smaller diameter. Impressions #1 and #4 were missing unique characteristic #3 (the curled scratches located on the top right side on the last "A" of "CANADA"). Even with one unique characteristic absent, the chances of having five other unique characteristics present on any other Toonie would be highly unlikely. Because there was still a high degree of association between the cast impression and the Toonie, an "identification" evaluation was given to all Mikrosil impressions (Figure 4).

Of the five casts created from dental stone, only impression #1 had one unique characteristic. However, all five cast impressions contained all four class characteristics identified on the Toonie. Although "identification" could not be made, the dental stone had the class characteristics to be given a "could have made" grading (Figure 5).

Three of the five casting impressions made by AccuTrans contained all the class and unique characteristics from the Toonie. Impression #1 was missing unique characteristic #3 and impression #5 was missing unique characteristic #5. Impression #5 was missing a unique characteristic because of an air pocket in the impression, which resulted in the characteristic being omitted. An "identification" evaluation was given to all AccuTrans impressions (Figure 6).

Grade Level	Description
Identification	This opinion means that a specific object made the impression evidence to the exclusion of all other objects. It contains the highest degree of association to a specific object.
Probably Made	This opinion means that the evidence is very persuasive that a specific type of object made the impression, yet some critical feature or quality is missing so that identification is not in order.
Could Have Made	This opinion means that there is significant association of multiple class characteristics between the cast impression and the object in question.
Inconclusive	This opinion means that there are significant limiting factors that do not permit a specific association between the impression evidence and the object in question.
Probably Did Not Make	This opinion means that the impression evidence is very persuasive that a specific type of object did not make the impression. However, the impression lacks sufficient quality for exclusion.
Exclusion	This opinion means that the particular object did not make the impression. This is the highest degree of non-association expressed in impression evidence examinations.
Unsuitable	This opinion means that impression lacks sufficient detail for a comparison

Table 1

Standard terminology for expressing conclusions of forensic footwear and tire impression examinations [2].

Coin Impressions	Class				Unique					
	#1	#2	#3	#4	#1	#2	#3	#4	#5	#6
ReproRubber "Thin Pour" #1	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Thin Pour" #2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Thin Pour" #3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Thin Pour" #4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Thin Pour" #5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Medium Body" #1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Medium Body" #2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Medium Body" #3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Medium Body" #4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ReproRubber "Medium Body" #5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mikrosil #1	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Mikrosil #2	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mikrosil #3	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mikrosil #4	N	Y	Y	Y	Y	Y	N	Y	Y	Y
Mikrosil #5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Dental Stone #1	Y	Y	Y	Y	N	N	Y	N	N	N
Dental Stone #2	Y	Y	Y	Y	N	N	N	N	N	N
Dental Stone #3	Y	Y	Y	Y	N	N	N	N	N	N
Dental Stone #4	Y	Y	Y	Y	N	N	N	N	N	N
Dental Stone #5	Y	Y	Y	Y	N	N	N	N	N	N
AccuTrans #1	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
AccuTrans #2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
AccuTrans #3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
AccuTrans #4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
AccuTrans #5	Y	Y	Y	Y	Y	Y	Y	Y	N	Y

Table 2

Detailed three-dimensional comparison of cast impressions to Toonie.
"Y" = characteristic was present in the cast impression.
"N" = characteristic was absent in the cast impression.

Conclusions

All of the tested casting materials, with the exception of dental stone, proved to be effective methods for casting detailed three-dimensional impressions from the coin.

Because of time constraints placed on the research, the scope of the research had to be limited to only one factor: comparing detailed three-dimensional impressions made with different casting materials. Environmental conditions were not taken into consideration, because impressions were formed in laboratory conditions. Other factors such as hardening time, vertical surface compatibility, and dimensional stability over long periods of time were not considered in this research. A future study on casting materials could focus on other areas that were not considered for this research.

Despite the limiting factors, this research impacts the forensic science community because it involves materials that are currently being used by forensic investigators. The forensic investigation team will gain knowledge pertaining to which materials to use or avoid when encountering detailed three-dimensional impression evidence.

For further information, please contact:

Wade Knaap
147 Allan Street
Port Perry, Ontario
L9LIE3
Canada
wadeknaap@hotmail.com

References

1. Du Pasquier, E.; Hebrard, J.; Margot, P.; Ineichen, M. Evaluation and Comparison of Casting Materials in Forensic Sciences: Application to Tool Marks and Foot/shoe Impressions. *For. Sci. Int*. **1996**, *82* (1), 33-43.
2. Standard Terminology for Expressing Conclusions of Footwear and Tire Impression Examinations. Scientific Working Group on Shoeprint and Tire Tread Evidence, SWGTREAD: Quantico, VA, March 2006.
3. Dental Casting Materials for the Recovery of Toolmark Impressions/Products. Royal Canadian Mounted Police Bulletins. http://www.rcmp-grc.gc.ca/firs-srij/bulletins/dent-cast-moul-eng.htm. (accessed April 20, 2008).
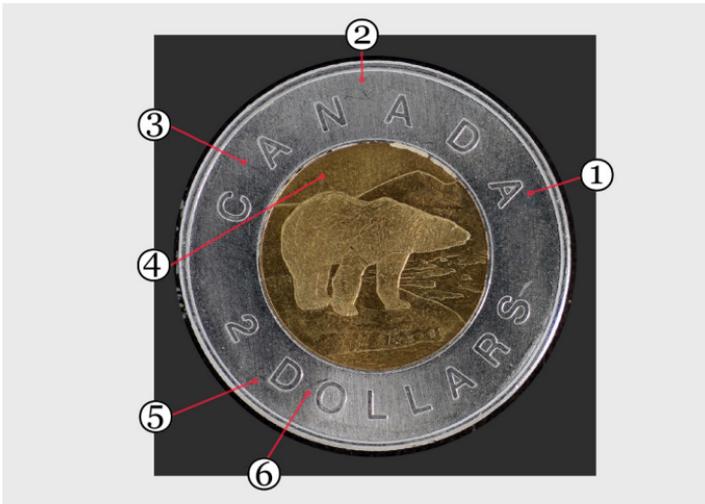
Figure 1

Canadian two-dollar coin: "Toonie".
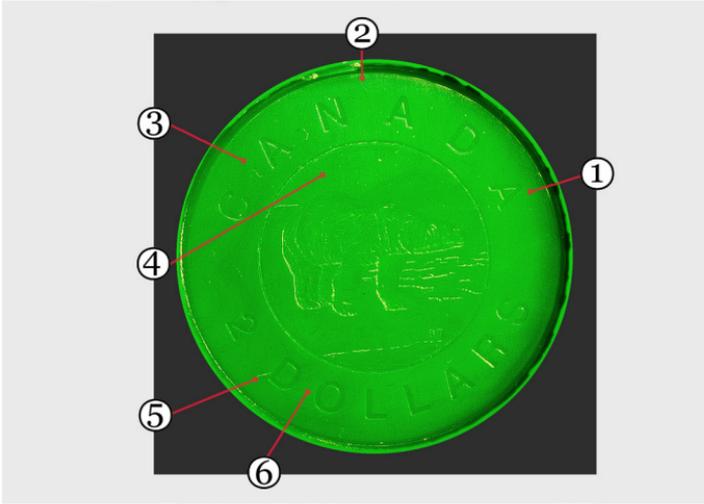
Figure 2
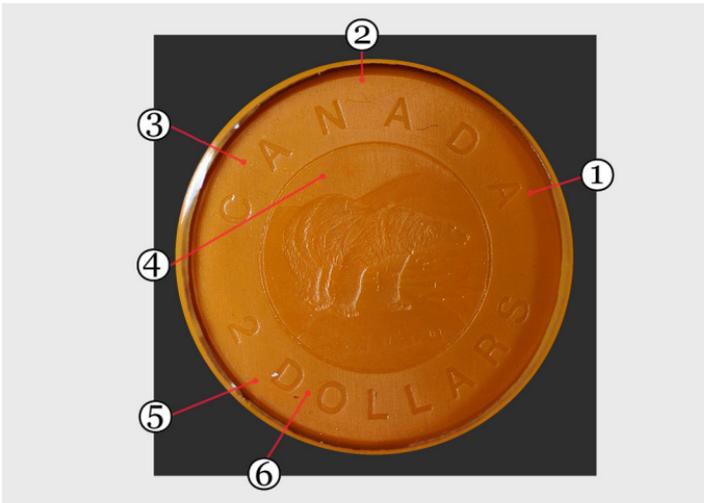
ReproRubber green "Thin Pour".

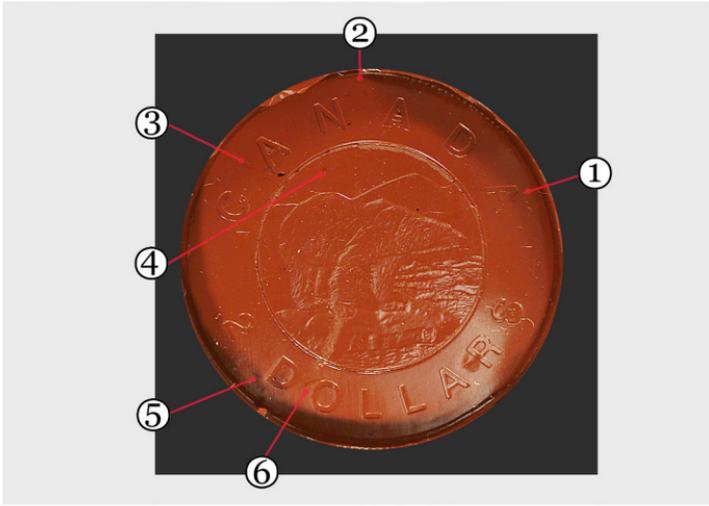*Figure 3*

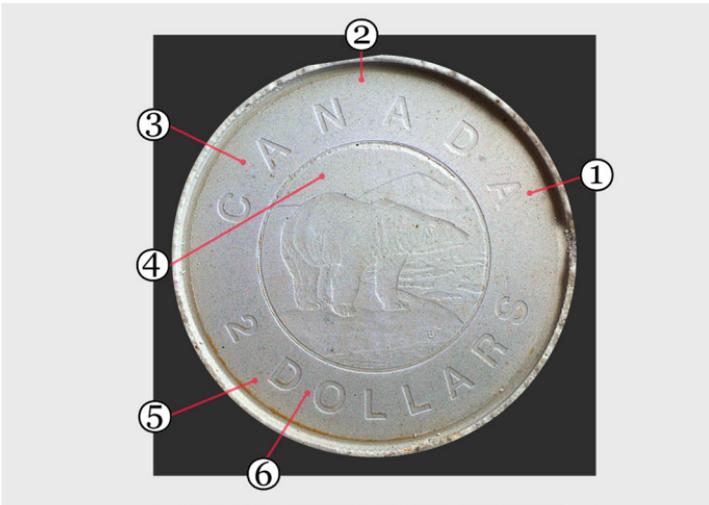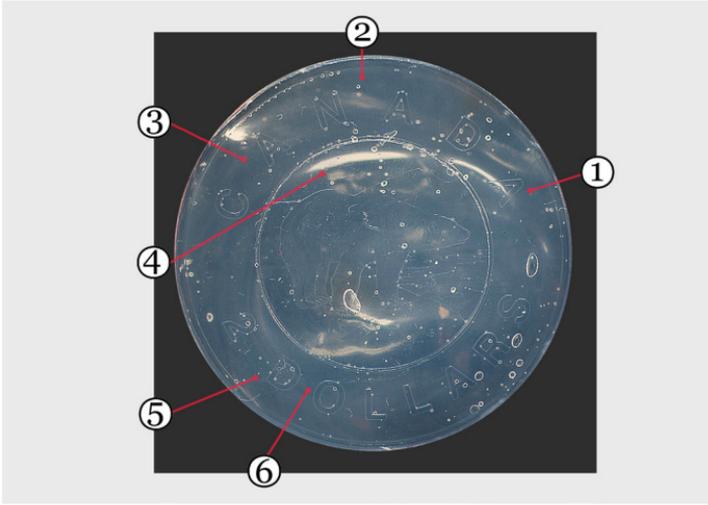*ReproRubber orange "Medium".*

Figure 4

Mikrosil brown.

Figure 5

Dental stone white.

Figure 6

AccuTrans clear.