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A NEW BALLISTIC SIMULANT "TRANSPARENT GEL CANDLE" (EXPERIMENTAL STUDY)

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ABSTRACT

Background: *Inanimate tissue simulants have been used to show the bullet effects in ballistic studies. Gelatin has been being used as a ballistic simulant for the last 20 years. It was considered that transparent gel candle (kraton in white paraffin oil) might be used as a soft tissue simulant that can be an alternative for gelatin.*

Methods: *For calibration of transplant gel candle, first it was shot at the 10% ordnance gelatin at 4 °C, and several concentrations of the transparent gel candle at 4 °C, by using a competition air gun. It was seen that 15% kraton in 85% white paraffin oil is the most suitable concentration. This kind of transparent gel candle blocks tested by using 9 mm parabellum and 7.62 mm x 51 (NATO 7.62) infantry rifle bullets and high-speed camera.*

Results: *Because of its transparency and elasticity, the penetration, permanent and temporary cavities of bullets were observed clearly in transparent gel candle.*

Conclusions: *As a result, transparent gel candle is a good soft tissue simulant that it can be used in wound ballistic studies.*

Key words: *ballistic, simulants, transparent gel candle*

INTRODUCTION

A number of substances have been used as tissue simulants such as wood, clay, soap and paraffin to study bullet effects.[1-3] Despite they show the cavities, in fact they are not soft tissue models since they are inelastic and hard solid.[1,2]

It was reported that gelatin is the only tissue simulant which both permanent and temporary cavities can be measured.[1] 10% gelatin at 4 °C has been used successfully in ballistic studies for a long time.[1,4]

Transparent gel candle is a gift object which can be found in most shopping centers. It is composed of kraton and white paraffin oil.[5] It was invented by Morrison D.S and Heilman W.J (patent appl. Num: 798,946) in TX ,USA in 1997.[5] Kraton is a termoplastic rubber polimery and Kraton RTM G is that second generation kraton (producted by Shell Chemical Company, France) that called 'Elastomer', is used in the production of transparent gel candle.[5] It is nearly transparent and strongly elastic.[5] It was tested the first in literature as a soft tissue model in ballistic studies.

MATERIAL AND METHODS

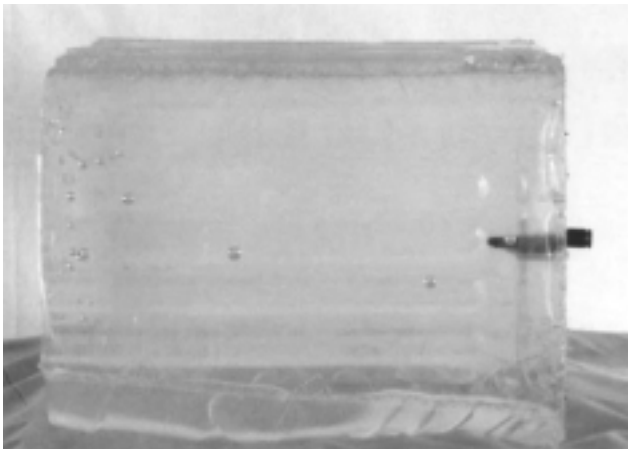
The study was performed in Gülhane Military Academy of Medicine, Criminal Police Labratory of National Police HQ and Karapınar Polygon of Turkish Army in 2001-02.

We prepared 10x15x25 cm diameters of 250 Type A ordnance gelatin blocks (Kind&Knoks P.O.Box 927 Sioux City Iowa USA). After we cooled gelatin blocks for 48 hours at 4 °C, we shot at these blocks by using a competition airgun (velocity: 154 m/sec, diameter: 4.5 mm). After 10 times shooting, it was seen that all pellets penetrated gelatin to the depth of 6.9±0.2 cm (Table 1).

Table 1. The penetration depth of airgun pellets

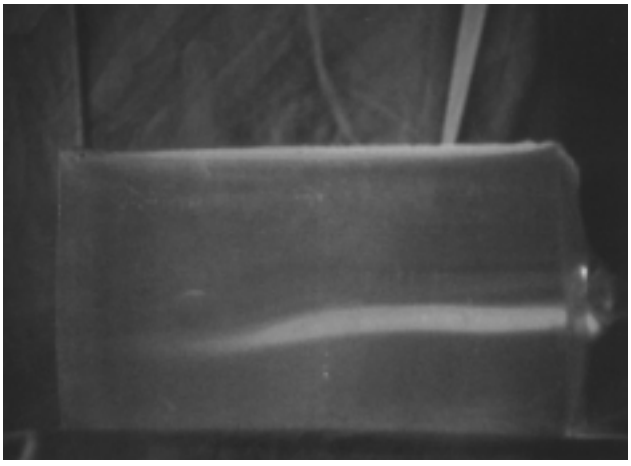
Target	Number of Shots	Depth of Penetration (cm)
10% Ordnance gelatin 4 °C	10	6,9±0.2
11% Transparent Gel Candle	10	11±1.3
13% Transparent Gel Candle	10	7±0.3
15% Transparent Gel Candle	10	4,8±0.1

We also prepared different concentrations (11-13-15%) of transparent gel candle blocks. For this purpose, white paraffin oil 85% and kraton 15% was mixed and heated until 110 °C and kraton was added in it slowly when it mixed and they were left for cooling in 4 °C temperature for 24 hours. After 10 shots at to each different candle blocks with same airgun, pellet and range, we found that 15% kraton and 85% white paraffin oil was the most suitable concentration due to the depth of penetration which was 7.0±0.3 cm (Table 1).

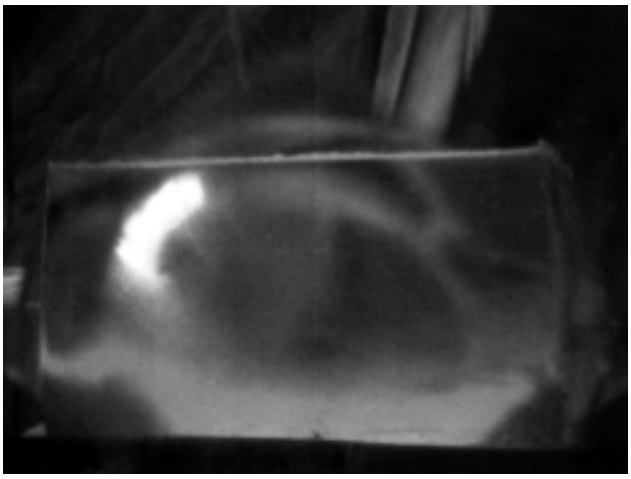


Picture 1. Shows transparency of transparent gel candle block

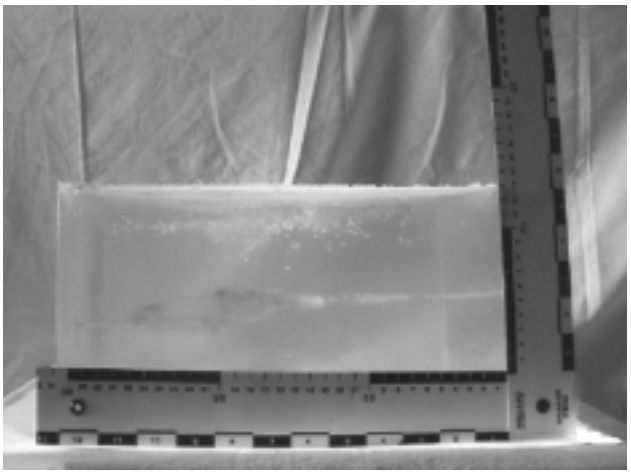
Calibrated transparent gel candle blocks (30x20x20cm) were prepared. They had excellent transparency like water and we stuck a bullet with cartridge case to show this special feature (Picture 1). At first, we tested them by using 9 mm parabellum's bullet (MKEK, 8 g, 350 m/sec. Initial velocity) and high-speed digital camera (Kodak-Ektapro Imager 1000 HRC) in 1000 image Per second. The penetration and the temporary cavity about 3 cm diameter and the permanent cavity were determined plainly (Picture 2). Second, NATO 7.62 mmx51 (velocity: 840 m/sec, bullet weight: 9.1 gram) bullets were tested with the same kind of blocks and high-speed camera. After the shot, much more wider temporary cavity and permanent cavity were seen perfectly (Pictures 3-4).



Picture 2. Temporary cavity produced in transparent gel candle block by 8 g, 350m/sec 9mm Parabellum bullet.



Picture 3. Temporary cavity produced in transparent gel candle block by 9.1 g, 840m/sec 7,62x51mm NATO bullet.



Picture 4. Permanet cavity produced in transparent gel candle block by 9.1 g, 840m/sec 7,62x51mm NATO bullet.

DISCUSSION

A simulant may be hard or soft solid.[2,6] The advantages of hard solids (clay, soap, paraffin) are that the temporary cavity becomes permanent cavity because of no collapsing and the measurement of the volume of cavity is easy.[6] But they have a great resistance against the bullet penetration that means smaller penetration depth, smaller cavity volume and easier fragmentation.[6]

Although paraffin is one of the first used tissue simulants in literature, ordnance gelatin and glycerin soap are the widely used tissue simulants.[2,7] Ordnance gelatin is a tissue simulant, which has been proven to have a close correlation with living tissue.[8] It is reported that no significant difference can be discerned between the soft soap and animal tissue as regards their influence on the behavior of the bullet.[9] Most users of ordnance gelatin for ballistic studies are apparently unaware of the detrimental effects on this tissue simulant,s properties caused by excess heating reconstitution of gelatin powder.[10]

It may be seen that the simulation of non-homogeneous body tissues is too hard to technically simulate and the variations between non-homogeneous body tissues and homogeny simulants may be considered a big problem, but it is not significant in practice.[6] The effects of bullet when it penetrates tissue or tissue simulants must produce similar forces. "This similarity can never be exact but must be nearly".[6] The simulant should cause the same projectile, must stop at the same penetration depth as in live tissue and similar penetration depth in simulant and in soft tissue is a very good demonstration of ballistic equivalence.[6,11] 10% 250 type A ordnance gelatin at 4 ^{0}C and leg muscle of freshly killed pig tested by using air guns.[6] It was suggested that 10% gelatin is the most suitable simulant because the depth of pellets were same in both muscle and gelatin.[1,6] We used the same methods between 10% ordnance gelatin and 11,13,15% transparent gel candle by using airgun and we got the same penetration depth in 15% concentration.

A visible simulant like gelatin has great advantage when compare with body tissues and hard solid simulants since the cavities can be observed when performing the dynamic ballistic studies[2,6] Like ordnance gelatin, transparent gel candle is well visible and the cavities of the bullets of pistol and infantry rifle were determined clearly although the speed of camera is not too fast. These images are important for understanding the bullet effects particularly the temporary cavity.

The ballistic studies difficult to perform but promising and transparent gel candle can be used in these studies as a soft tissue simulant.

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