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Original Article

How were lipofilling cannulae designed and are they as safe as we believe?

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ABSTRACT

Background: Most practitioners in plastic surgery believe that blunt tipped cannulae are safer. Interestingly, there is no study about their safety, and the problem is exactly this. As the use of blunt tipped cannulae is somehow difficult, some surgeons try other extreme alternatives, such as sharp and cutting tipped injection needles. But, they can cause complications such as vessel damage. According to these hypotheses, we tried to design a cannula which would ease the application of lipofilling and which would minimise the trauma. Contrary to the injection needle, the tips of the cannula would be blunter, and trauma would be diminished. **Objectives:** After designing such a cannula, we compared it with the most frequently used Coleman type cannulae with regard to ease in utilisation, and safety. We also tried to evaluate the potential for trauma, of the regularly used cannulae. **Materials and Methods**: In the first part, the penetration capacity of all cannulae was measured and compared, and in the second part, the tissue damage was evaluated in an experimental model. **Results:** According to the statistical and histological findings, the pointed-tip cannulae, blunted to a certain degree, can be applied easily through the tissues. The surgeon works more comfortably and we have noted that these cannulae cause less tissue damage.

KEY WORDS

Cannula tip; fat graft; microinjection cannula

INTRODUCTION

Every plastic surgeon is aware of the cannulae used for lipofilling, and most practitioners believe that the blunt tipped cannulae are safe. Interestingly,

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there is no study about their safety, and this is where the problem lies. It is not known why cannulae were designed with blunt tips. Some examples from daily life are contradictory to the idea of blunt tipped objects being safer. For example, blunt tipped bullets are preferred in order to cause more destructive trauma. Also, the sides of the canoes in a river unite with an angle of 30° at the front, and these pointed tipped canoes "cleave" through the bush smoothly without destroying them [Figure 1].

As the application of blunt tipped cannulae is somehow difficult, some surgeons try other extreme alternatives such as sharp, and cutting tipped injection needles. They act as scalpels because their edges are sharp, and they can rupture vessels and cause bleeding and hematoma, specially in areas rich in vascular supply, such as the face. There are studies which show that the sharp tipped cannulae can even cause blindness.[1] Probably, this is the reason for the phobia against the more pointed tipped cannulae and for the resultant faith in the blunt tipped cannulas. Based on these observations, we tried to design a cannula which would ease the application of lipofilling, and also minimise trauma. As against the injection needle, the edges or tip of the cannula would be blunter. After designing such a cannula, we compared it with the most frequently used type 1 and 3 Coleman type cannulae in the aspects of ease in utilisation, and safety. We also tried to show the potential for trauma, of the Coleman type 1 and 3 cannulae.

MATERIALS AND METHODS

As a pilot study to test the ease of utilisation of the new cannula, black polyether foam (175 density-pound per cubic foot [PCF]) was used in order to measure and compare the penetration capacities of all the cannulae [Figure 2]. A mini pressure-measurer is mounted on the cannulae. The black polyether foam is penetrated 10 times with back and forth movement of the cannulae. Pressures are measured at each penetration and mean pressure values are calculated [Figure 2]. After noting the results, we proceeded to the second step of the study viz. evaluation of the tissue damage. Nine New Zealand white rabbits which weighed 1240 ± 290 g were chosen. The study was initiated after an ethics committee of the Bezmialem University Faculty of Medicine (numbered: 2012/750) approved of the study. Each animal received prescribed rabbit food, and water. Intramuscular ketamine (45 mg/kg) and xylazine (5 mg/kg) were applied for anaesthesia, and the study was performed under sterile conditions. Both the posterior thighs of the rabbits were shaved before incision. The animals were distributed into four groups:

1. Group 1 (Coleman type 1 — The most bluntly tipped cannula): The area with the highest muscle density was marked on the left anterolateral thigh of the rabbits [Figure 3]. After the step incision, the blunt tipped cannula was advanced until the muscle. The cannula

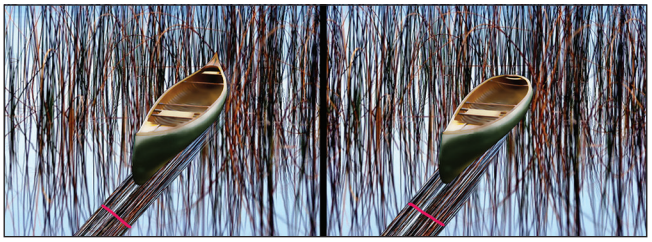

Figure 1: Left: Schematic illustration of the canoe with the 30° at the front tear less bush. Right: The canoe with wider angle at the front tear more bush

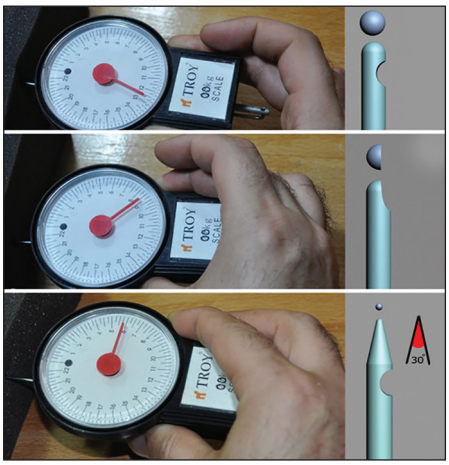

Figure 2: The measurement of the penetration capacities of the cannulas on black polyether sponge

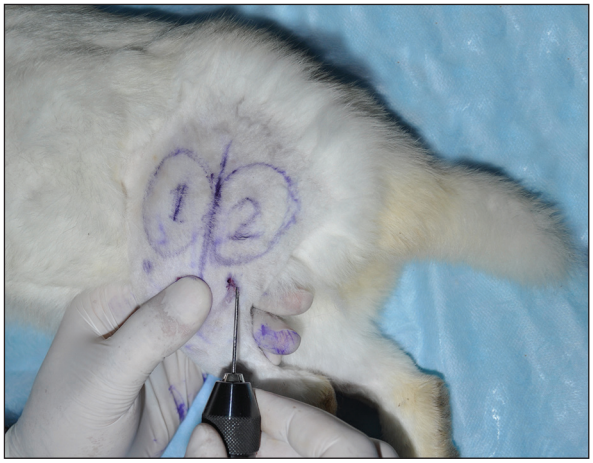

Figure 3: The markings of the left anterolateral and posterolateral of the rabbit's femur

was moved backwards, and forwards 20 times in a fan-shaped arc.

2. Group 2 (Coleman type 2 — Less bluntly tipped cannula): The same application done for Group 1 was done with Coleman type 2 cannula at the left posterolateral thigh of the rabbits.
3. Group 3 (the pointed tipped cannula designed by the author): The same application done for Group 1 and 2 was done with the more pointed cannula designed by the author at the right posterolateral thigh of the rabbits [Figure 4]. The pointed tipped cannula was designed pointed enough to facilitate the dissection. On the other hand, it was designed blunt enough to avoid neural and vascular injury in the surrounding tissue.
4. Group 4 (the control group without a cannula): This group includes the cutaneous, subcutaneous, and muscular biopsies taken from the right anterolateral thigh of the rabbits. With this group, the damage caused by the biopsy scalpel in the other three groups could be compared.

The central part of each of these four areas of every rabbit was biopsied 24 h after the application. In fact, this is the time required for demonstrating surrounding tissue damage at a cellular level. Muscle biopsies were taken in a diameter of 1 cm × 1 cm, and a depth of 0.5 cm. The rabbits were sacrificed with high doses of pentobarbital. The biopsy specimens were fixed in paraffin, and slices of 5 μm thick were prepared. The slides were stained with haematoxylin and eosin, and they were examined under the light microscope. The slides were evaluated histopathologically for the following parameters:

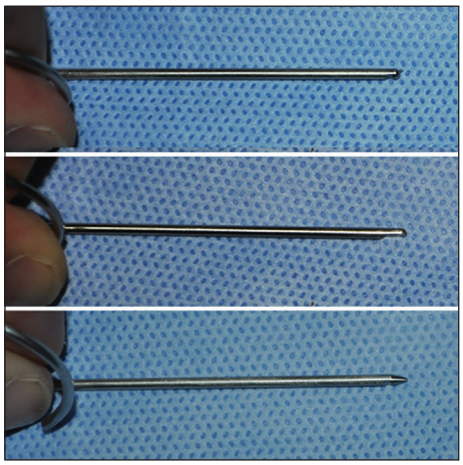

Figure 4: The cannulas used for the study. Above: Coleman type 1 cannula. Middle: Coleman type 2 cannula. Below: Pointed tipped cannula designed by the author

The presence of degeneration at the muscle cells, interstitial oedema, capillary congestion, haemorrhage, inflammation, and necrosis of the muscle tissue. The microscopic evaluation was done and graded as: Absent (−), mild (+), moderate (++), and severe (+++). The histopathologic evaluation was done , by a pathologist who was blinded to the groups. For the analysis of the data, the independent groups were compared with the Mann–Whitney U-test, and the JanckheereTerpstra test. The results were evaluated with the Statistical Package for the Social Sciences (SPSS 16) program.

RESULTS

The mean penetration capacities are 12 units for cannula 1 (Coleman type 1), 8 units for cannula 2 (Coleman type 2), and 6 units for cannula 3, designed by the author. With this data, it can be said that the tissue penetration is easier with cannula 3 (designed by the author) and that the target site is reached with less effort.

No difference was seen histopathologically in the control group (Group 4). The muscle penetrated by the cannula was infiltrated densely with neutrophils in Group 1. Less lymphocytes and other inflammatory cells were observed in these areas. Muscular degeneration, interstitial oedema, congestion, and haemorrhage were observed extensively in multiple areas [Figure 5a]. However, these changes were not observed in Group 2 and 3 overtly.

Muscle cell degeneration, oedema, inflammation, haemorrhage, and congestion were seen in few areas in Group 2 [Figure 5b]. Nearly no degeneration or inflammation was observed in Group 3 [Figure 5c]. Signs of necrosis were present in none of the groups. When the groups were compared with respect to degeneration

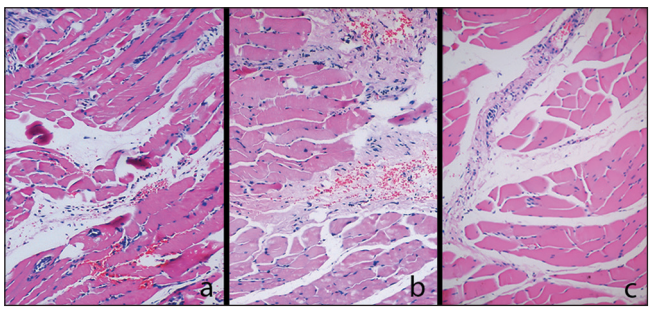

Figure 5: The results of the histopathologic evaluation of the groups: (a) The myocyte degeneration, the inflammatory cells between the muscle cells, and the interstitial oedema in Group 1 (H and E ×400). (b) The interstitial oedema and haemorrhage in a small area in Group 2 (H and E×100). (c) The slightly normal morphology and interstitial oedema in the muscle cells in Group 3

and inflammation, these parameters were found less in Group 2 and 3 than Group 1. In fact, this finding was statistically significant ($P < 0.005$). Also, they were less in Group 3 as compared to Group 2 [Table 1]. However, this finding was not statistically significant. The oedema values of Group 3 were less than in Group 1 and 2 and was statistically significant ($P < 0.005$). Congestion and haemorrhage rates were lower in Group 3 than the other groups, but not statistically significant [Table 2].

DISCUSSION

Fat injections have been used since 1893,[2] and this procedure is frequently performed in the practice of Plastic Surgery. If we evaluate the difficulties faced by the surgeons during such a frequently practiced method, we will see that one of the biggest problems is the difficulty in the actual injection. . The main reason is that blunt tipped cannulae which are thought to be safer cannot be manipulated easily inside the tissue. The cannulae must be pushed with high pressure in order to reach a specific target point, and there is the risk of inability to reach the target. If the fat graft injection is being performed in a scarred tissue, the mentioned problems will be even more difficult. Pitch-forked dissected cannulas or V-dissected cannulas are designed and modified by Toledo and Coleman for fat delivery and Rigottomies have been described.[3] However, in his study, Coleman[2,4] found that one of the main principles of increasing the viability of the fat grafts, is injecting the fat into various areas and into different layers in minimal amounts. In accordance with this principle, some surgeons aimed to reach the target area with greater ease in order to obtain more durable results, and they utilised various methods. In fact, some of them preferred sharper tipped cannulae with a higher risk of penetrating the blood vessels, and some of them used injection needles directly with a high risk of vascular damage and hematoma because of the sharp edges. In literature, permanent blindness due to retinal artery injury or embolism, stroke, forehead or nasal skin necrosis are reported, but the methods of the injections were not mentioned.[1,5,6] All of these catastrophic findings cautioned the practitioners, and despite the difficulties in application, they preferred blunt tipped cannulae. A pointed tipped cannula whose tip is blunt enough not to pierce the vascular structures would move through the tissues easily and would be preferable. The lipofilling is often performed on the face, and while the pointedness of the cannula was being ascertained, 1 mm was the mean diameter of the facial blood vessels.[7] Thus, the tip of the cannula was 1 mm, and the body diameter of the cannula was 3 mm. The body diameter of the cannula may vary according to the intended use in the face. But, the fact to be noted here is that the pointedness of the tip of the cannula must be 1 mm in diameter. Also, we designed the tip of our cannula with an angulation of 30°. There is no standard angulation for canulae used for penetration. Again, inspired by nature we tried to design the tip of our cannula like the canoe. We believe that this cannula may be designed with various thickness (at both tip and the port of the cannula) and pointedness at its tip and diameters depending on the area of lipofilling.

Table 1: The statistical comparison of the muscle degeneration and inflammation in the four groups

P (general) = 0.000***	***Group***			
	A = Cannula 1	***B = Cannula 2***	***C = Cannula 3***	***D = Control***
Degeneration				
Average	1.67	0.78	0.56	0.00
SD	1.12	0.67	0.53	0.00
Median	1.00	1.00	1.00	0.00
Maximum	3.00	2.00	1.00	0.00
Minimum	0.00	0.00	0.00	0.00
P (A-D)=0.000***; *P* (B-D)=0.004**; *P* (C-D)=0.011*; *P* (A-B)=0.078 NS; *P* (A-C)=0.025*; *P* (B-C)=0.482 NS				
Inflammation				
Average	1.56	0.67	0.67	0.00
SD	0.88	0.71	0.71	0.00
Median	2.00	1.00	1.00	0.00
Maximum	3.00	2.00	2.00	0.00
Minimum	0.00	0.00	0.00	0.00
P (A-D)=0.000***; *P* (B-D)=0.011*; *P* (C-D)=0.011*; *P* (A-B)=0.036*; *P* (A-C)=0.036*; *P* (B-C)=1 NS				

Jonckheere–Terpstra test; Mann–Whitney test; NS: Nonsignificant; SD: Standard deviation

After the design process of the cannula was completed, the penetration capabilities were measured in order to compare it with the other available cannulae, and to study ease in lipofilling. We considered initially using excised abdominoplasty tissue for this measurement, but the thickness is not homogenous throughout the whole tissue. We could not standardise the penetration. For this reason, we preferred black polyether foam that is homogenous in composition and texture (175 density - PCF). As a result, we found that the new design cannula passes through the tissue even easier than the most frequently used Coleman type cannulae, including the most pointed tipped type 3.

In Coleman's original study, he explained the main factors that would increase the viability of the fat cells were the

Table 2: The statistical comparison of oedema, congestion and haemorrhage in the four groups

P (general) = 0.000***	***Group***			
	A = Cannula 1	***B = Cannula 2***	***C = Cannula 3***	***D = Control***
Oedema				
Average	1.33	1.11	0.89	0.00
SD	0.50	0.33	0.33	0.00
Median	1.00	1.00	1.00	0.00
Maximum	2.00	2.00	1.00	0.00
Minimum	1.00	1.00	0.00	0.00
P (A-D)=0.000***; *P* (B-D)=0.000***; *P* (C-D)=0.000***; *P* (A-B)=0.270 NS; *P* (A-C)=0.045*; *P* (B-C)=0.169 NS				
Congestion				
Average	0.89	1.00	0.89	0.00
SD	0.33	0.00	0.33	0.00
Median	1.00	1.00	1.00	0.00
Maximum	1.00	1.00	1.00	0.00
Minimum	0.00	1.00	0.00	0.00
P (A-D)=0.000***; *P* (B-D)=0.000***; *P* (C-D)=0.000***; *P* (A-B)=0.317 NS; *P* (A-C)=1 NS; *P* (B-C)=0.317 NS				
P (general)=0.029*				
Haemorrhage				
Average	0.89	0.56	0.67	0.00
SD	0.93	0.88	0.87	0.00
Median	1.00	0.00	0.00	0.00
Maximum	2.00	2.00	2.00	0.00
Minimum	0.00	0.00	0.00	0.00
P (A-D)=0.029*; *P* (B-D)=0.066 NS; *P* (C-D)=0.029*; *P* (A-B)=0.403 NS; *P* (A-C)=0.597 NS; *P* (B-C)=0.723 NS				

Jonckheere–Terpstra test; Mann–Whitney test; NS: Nonsignificant; SD: Standard deviation

harvesting techniques, the centrifuging techniques and the effect of the diameters of the cannulae.[2,8] However, it is now clear that the viability of the fat grafts is closely related to the properties of the recipient area, just like the skin grafts. During lipofilling, the procedure may cause a severe crush injury of the tissue at the donor site itself, but it is interesting to note that we could not find any studies about the recipient site which affects the nourishment of the fat cells. For this reason, we thought that it would be beneficial to assess objectively the histology of the damage caused to the tissues by these cannulae. We planned this study on the legs of the rabbits. The main reason why we preferred to work on the muscle tissue of the rabbits instead of the subcutaneous fat tissue is that the subcutaneous layer of the rabbits is very loose and all of the cannulae can pass through this layer without any difficulty. It would not be possible to distinguish the cannulae from each other with respect to trauma. Again, we saw that the cannulae that caused the most severe trauma are actually the blunt tipped ones that plastic surgeons trust the most.

As we have demonstrated in this study, the cannula with a better penetration capacity would reach the specific anatomical regions, like the periorbital area easily and with less trauma. As is seen in medical literature, a small amount of fat graft that is injected into deep dermis gives better results than a large amount of fat graft injected to the subcutaneous layer.[9]

According to the results of our study, the pointed tipped cannulae which are blunted to a certain degree can be applied easily through the tissues. The surgeon works more comfortably, and we have proven that these cannulae cause less tissue damage. As a next step, new studies can be designed in order to compare the viability of the fat grafts among different types of cannulae, and to see if the viability with the pointed tipped cannula is higher. As a result, we think that this cannula can deliver the fat graft to the desired area easily and safely.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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