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Identifying the most attractive umbilical position – an eye tracking- and survey-based investigation

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ABSTRACT

Abdominoplasty is a popular procedure in plastic surgery providing aesthetic, functional and psychological relief for patients suffering from excess abdominal tissue. Correct umbilical positioning is crucial for a successful aesthetic surgical outcome. This study aims to assess the most attractive position of the umbilicus by means of subjective and objective outcome measures. 58 Caucasian study participants with a mean age of 36.87 (15.6) years rated eight different umbilical positions. The various positions were determined based on the ratio of the distance between the xiphoid process and the umbilicus and the distance between the umbilicus and the infra-umbilical crease: 1:1, 1.25:1, 1.5:1, 1.75:1, 2:1, 2.5:1, 3:1 and 5.5:1. Semi-quantitative scoring of attractiveness based on a 5-point Likert scale and eye tracking analyses were utilized. The results revealed that the volunteers perceived as most attractive the ratio of 2:1 with 4.32 (out of possible 5.0). The ratio of 5.5:1 received the lowest rating with 1.8. The results of the objective eye tracking analyses confirmed the subjective rating as the 2:1 ratio was fixated last amongst all other displayed ratios with 1.85 s whereas the 5.5:1 ratio had the shortest interval between image display and first stable eye fixation with 0.94 s. The study confirms the concept of 'internal representation of beauty'. Abdominoplasty procedures could rely on this easy to perform ratio by dividing the distance into thirds and using the boundary between the inferior and middle third as a clinically reliable landmark.

Introduction

Abdominoplasty is a popular procedure in plastic surgery providing aesthetic and functional improvement as well as psychological relief for patients suffering from excess abdominal subcutaneous tissue, that is, skin and fat [1–3]. According to the American Society of Plastic Surgeons (ASPS), there was a 97% increase in the number of annually performed abdominoplasties between 2000 and 2019 [4], demonstrating the surge in demand of recent years for re-shaping the abdomen. In addition, the procedure is an essential part of reconstructive surgery, such as in donor site closure of DIEP flap breast reconstructions [5], or in ventral hernia repair [6].

A key step during abdominoplasty procedures involves the positioning of the umbilicus, as it plays an integral role in the perception of a physiologic and aesthetically pleasing abdominal surface. The umbilicus can be incised, separated from the abdominal skin and repositioned after the excess abdominal tissue has been removed. While reinserting of the umbilicus is then often determined by the umbilical stalk attached to the abdominal wall, there can be significant stretch in patients after massive weight loss, allowing for a range of placement. Alternative techniques transect the stalk of the umbilicus while prevailing its position within the abdominal skin ('umbilical float-technique'), or leave the umbilicus and its stalk in place (standard mini-

abdominoplasty) thereby locating the umbilicus inferiorly when stretching the abdominal tissue inferiorly [7–9].

While there is abundant literature on the performed surgical techniques, limited attention was directed in recent research toward the aesthetic position of the umbilicus. In 1978, Dubou et al. [10] suggested that the repositioning of the umbilicus should be in accordance with anatomic landmarks which should be the mid-way between the iliac crests. Interestingly, two independent articles suggested later on using the 'golden ratio' (1.618:1) when estimating the correct umbilical position while measuring the distance to the xiphoid process [11,12]. Whereas Abhyankar et al. [11] suggested using the pubic symphysis as the inferior landmark, Visconti et al. [12] suggested using the abdominal crease as the inferior landmark. However, both studies were not free of limitations: Abhyankar et al. based his conclusion on the analysis of 75 Indian cosmopolitan females whereas Visconti et al. used 81 high quality pictures of top 2013 bikini models when chosen by editors of mass media. The reliability of such images due to image post-editing and the general applicability to the Caucasian, Asian or African American population of the results presented remains unfortunately questionable.

Because *beauty is within the eye of the beholder* [13], the assessment of the most aesthetically pleasing umbilical position should be based on subjective assessment but also on objective outcome data. Therefore, this study was designed to investigate
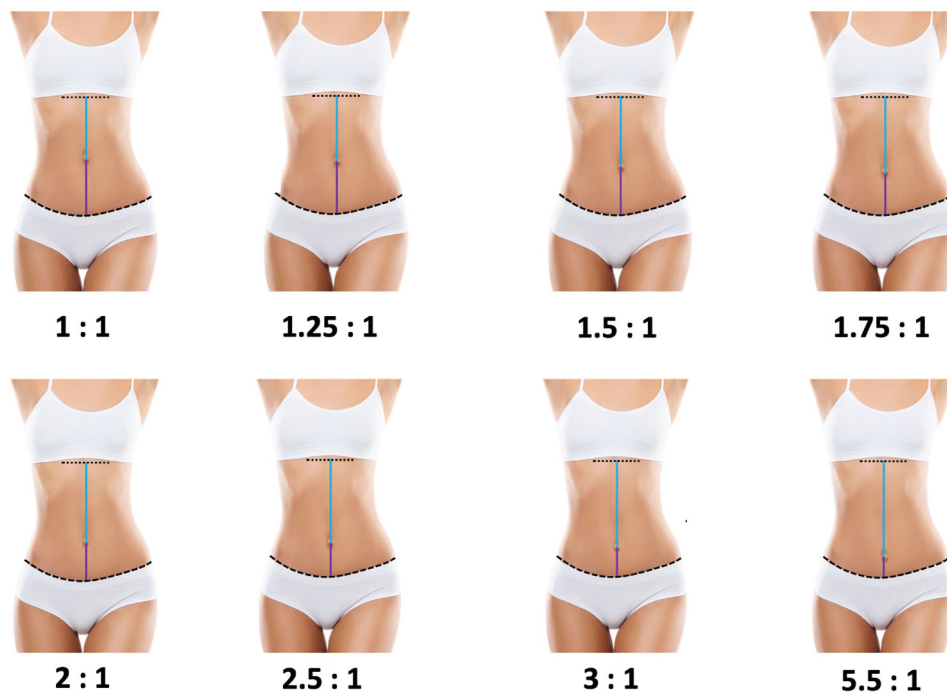
Figure 1. Composite Figure showing the different vertical umbilical positions based on the ratio of the distance between the skin projection of the xiphoid process and the umbilicus (= XU) and the distance between the umbilicus and the infra-umbilical crease (UC). The following XU:UC ratios were displayed: 1:1, 1.25:1, 1.5:1, 1.75:1, 2:1, 2.5:1, 3:1 and 5.5:1.

umbilical positioning using semi-quantitative scoring based on a 5-point Likert scale and eye tracking technology to capture gaze patterns and fixation times of study volunteers [14]. It is hoped that the results of this study will allow surgeons to identify the most aesthetic location of the umbilicus during abdominoplasty procedures based on reliable and reproducible data collection.

Materials and methods

Study sample

Eye-movement analyses were conducted in a total of 58 Caucasian volunteers (n = 21 (36.2%) males and n = 37 (63.8%) females) with a mean age of 36.87 (15.6) years [age range: 19–70]. Volunteers were recruited at REDACTED of which n = 12 (20.7%) were plastic surgeons and n = 46 (79.3%) were without medical background.

Prior to the initiation of the study, volunteers were informed about the aim and the scope of this study and provided written informed consent for the use of their research- related and demographic data. The study was approved by the Institutional Review Board of REDACTED (IRB protocol number: 20-1018).

Eye movement analysis

The utilized eye-tracking device was a Tobii Pro Nano binocular eye – tracker (Tobii Pro AB, Stockholm, Sweden) and operated at a frequency of 60 Hz. The device was mounted at the bottom of a 15" commercially available laptop monitor (Surface Laptop 3, Microsoft, Redmond, WA, US) with a screen size of 340 mm × 244 mm. Eye movements of the study volunteers were captured within a distance of 65 cm to the monitor and a lateral and cranial distance of 35 cm × 30 cm, as published previously [15].

Visual stimulus presented

To identify differences in eye movement patterns between the 58 volunteers, eight different images (= visual stimulus) of umbilical positions were displayed for the duration of 6 s with a resting interval of 2 s between each of the images to allow for eye movement re-positioning. The eight images displayed, presented different vertical positions of the umbilicus in the midline in the same female patient. The various positions of the umbilicus were determined based on the ratio of the distance between the skin projection of the xiphoid process and the umbilicus (= XU) and the distance between the umbilicus and the infra-umbilical crease (UC). The following XU:UC ratios were displayed: 1:1, 1.25:1, 1.5:1, 1.75:1, 2:1, 2.5:1, 3:1 and 5.5:1 (Figure 1).

The various umbilical ratios were edited with Adobe Photoshop Version 21 (Adobe Inc., San Jose, California, USA) based on a commercially acquired stock image. The decision to choose the upper margin of the white underwear as the imaginary position of the infra-umbilical crease was based on the surgical experience of the authors where the scar post abdominoplasty is intended to be hidden slightly inferior to a horizontal connecting line between the anterior superior iliac spines. If the scar is hidden below that line the remainder of visible abdomen can be regarded as the aesthetic area of interest in which the vertical position of the umbilicus can be evaluated.

Data analysis

Eye movement pattern analysis

Eye movement pattern was captured and processed by the internal software toolkit and allowed for the analysis of the following parameter (Figures 2 and 3):

- Time until first fixation (interval between initial display of the image and the first stable eye fixation on the umbilicus)
- Time of fixation (duration of a stable eye fixation on the umbilicus within the time of visual stimulus exposure = 6 s)

Figure 2. Figure showing the 2:1 ratio (left) and the respective visual overall gaze pattern of all subjects (right) when looking at the image.

Figure 3. Figure showing the 5.5:1 ratio (left) and the respective visual overall gaze pattern of all subjects (right) when looking at the image.

Aesthetic rating

Additional to the eye movement analysis, the 58 study participants were asked to rate the eight different umbilical positions according to a 5-point Likert scale: (1) very unattractive, (2) unattractive, (3) neutral, (4) attractive, and (5) very attractive.

Statistical analysis

Differences in time until fixation and time of total duration of fixation and Likert – Scale rating across the different umbilical positions were assessed using analysis of variance (ANOVA) with post-hoc Tukey testing. Pearson – correlations were performed between Likert Scale rating and time until fixation and time of total duration of fixation. All calculations were performed using SPSS Statistics 26 (IBM, Armonk, NY, USA) and results were considered statistically significant at a probability level of ≤0.05 to guide conclusions.

Table 1. Table showing the outcome of the aesthetic rating, time to first fixation (in seconds), and the duration of fixation during the 6 s visual stimulus exposure interval (in seconds) for distance between the skin projection of the xiphoid process and the umbilicus (= XU) and the distance between the umbilicus and the infra-umbilical crease (UC). Results are presented as mean value and the corresponding standard deviation.

XU:UC ratio	Aesthetic rating	Time until first fixation	Duration of fixation
1:1	3.78 ± 0.8	1.49 ± 1.3	1.51 ± 1.2
1.25:1	3.25 ± 1.0	1.65 ± 1.6	2.05 ± 1.5
1.5:1	2.43 ± 1.0	1.29 ± 1.5	2.18 ± 1.4
1.75:1	3.98 ± 1.0	1.45 ± 1.2	1.77 ± 1.5
2:1	4.23 ± 1.0	1.85 ± 1.4	1.76 ± 1.6
2.5:1	3.59 ± 1.2	1.28 ± 1.3	1.68 ± 1.4
3:1	2.89 ± 1.2	1.09 ± 0.9	2.47 ± 1.5
5.5:1	1.81 ± 1.0	0.94 ± 1.0	3.38 ± 1.6

Results

General findings

No statistically significant gender differences were observed for the time until first fixation and the aesthetic rating with $p > 0.566$. Overall, females had a statistically significant longer total fixation time with 2.51 (1.7) s vs. 2.11 (1.5) s when compared to males (out of the 6 s visual stimulus exposure interval) with $p = 0.003$.

There was no statistically significant difference in any of the evaluated variables when comparing the background (plastic surgeons vs non-medical background) of the volunteers included into the study with $p > 0.115$.

Aesthetic rating

The 2:1 ratio (XU:UC) received the highest aesthetic rating based on the 5-point Likert scale with a mean value of 4.32 (1.0) (1 to 5, worst to best). On the contrary, the 5.5:1 ratio was rated lowest with a mean value of 1.81 (1.0) when compared to all other scored ratios with $p < 0.001$. Details on the individual aesthetic ratings are given in Table 1 and Figure 4.

Time to first stable eye fixation

The shortest interval until the first stable eye fixation occurred was identified for the 5.5:1 ratio (XU:UC) with an average duration of 0.94 (1.0) s while the longest interval was observed for the 2:1 ratio with 1.85 (1.4) s. Overall differences between measurements indicated statistically significant different intervals with $p = 0.017$ (Table 1) (Figure 5).

Duration of stable fixation

The longest duration of a stable eye fixation was found for the 5.5:1 ratio (XU:UC) with a mean duration of 3.38 (1.6) s while the shortest duration was found for the 1:1 ratio with a mean duration of 1.51 (1.2) s. Overall differences between measurements indicated statistically significant different intervals with $p < 0.001$ (Table 1) (Figure 6).

Additional observations

A positive correlation was observed between the aesthetic rating and the interval between visual stimulus exposure and first stable eye fixation with $r_p = 0.321$ and $p < 0.001$ (Figure 7). Interestingly, a negative correlation was observed between the aesthetic rating and the total duration of a stable eye fixation with $r_p = -0.481$ and $p < 0.001$ (Figure 8).
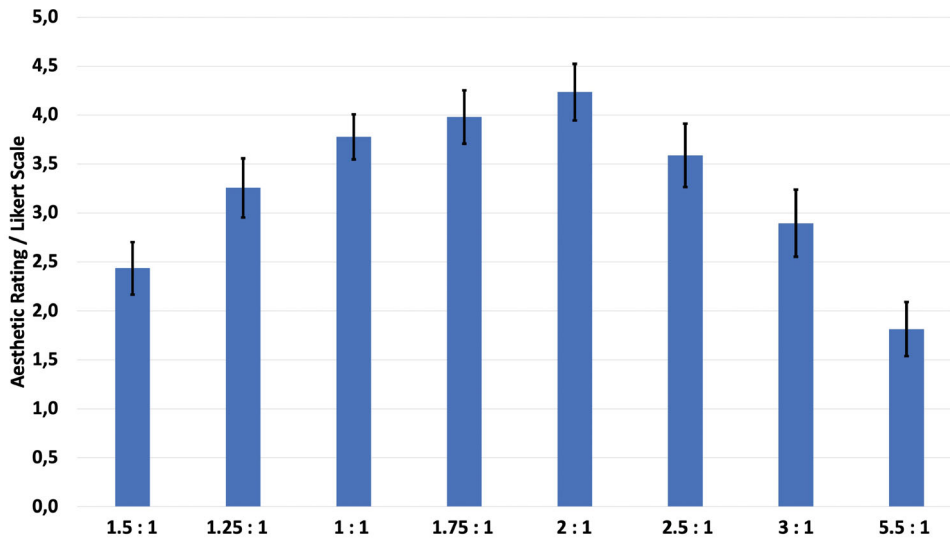
Figure 4. Bar graph showing the aesthetic rating for the respective XU:UC ratios (SD).
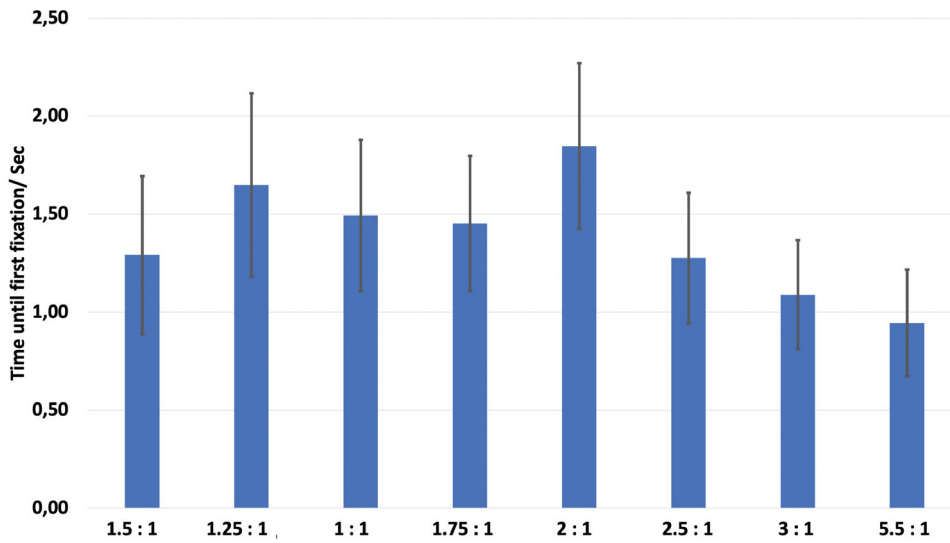

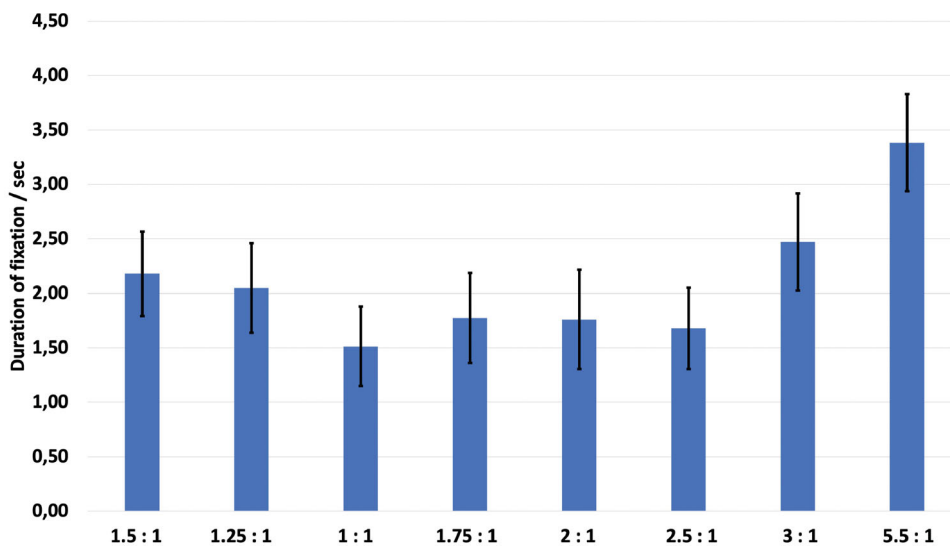**Figure 5.** Bar graph showing the mean time until first fixation for the respective XU:UC ratios (SD).

Figure 6. Bar graph showing the mean duration of fixation for the respective XU:UC ratios (SD).
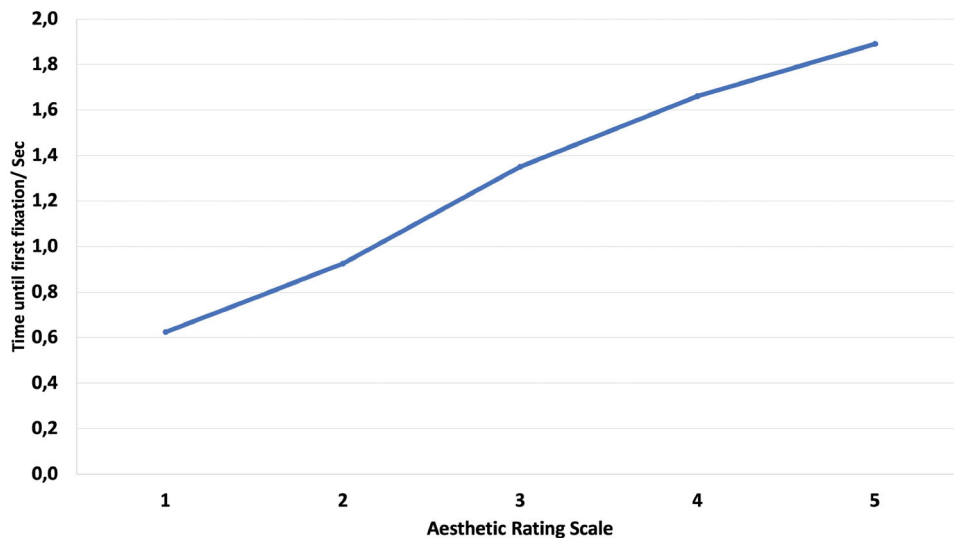
Figure 7. Line graph showing the strong positive correlation between aesthetic rating and time until first fixation.
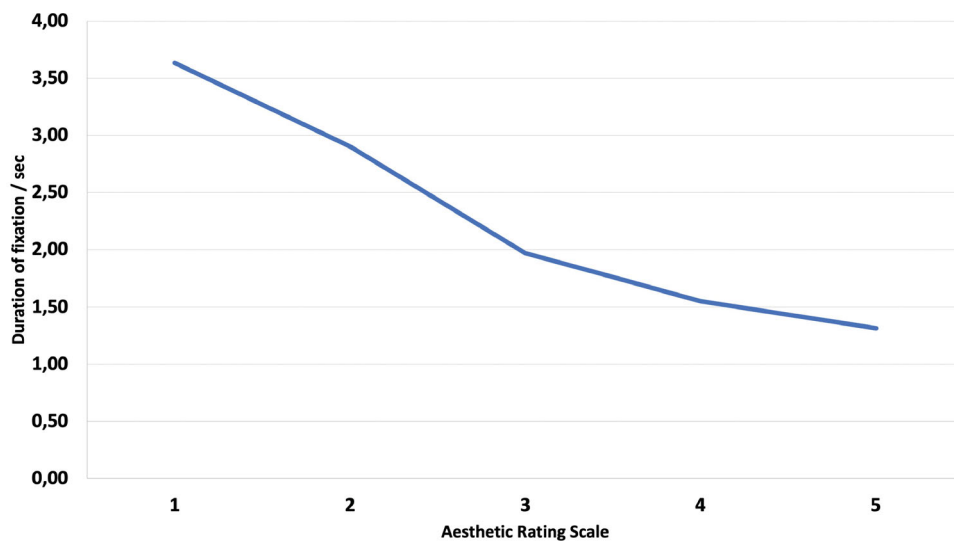

Figure 8. Line graph showing the strong negative correlation between aesthetic rating and duration of fixation.

Discussion

This study investigated the most aesthetically appealing position of the umbilicus in a sample of 58 Caucasian volunteers by means of semi-quantitative aesthetic rating (5-point Likert scale) and by eye tracking analyses. The umbilical position was modified by photo editing and varied along a vertical axis in the midline of a female Caucasian stock image with different ratios between the skin projection of the xiphoid process and the umbilicus (= XU) and the distance between the umbilicus and the infra-umbilical crease (UC). The results revealed that the volunteers perceived as most attractive the ratio of 2:1 (XU:CU) with 4.32 (out of possible 5.0) indicating that if the distance between infra-umbilical crease and the xiphoid process is divided into thirds, the most aesthetically appealing location would be between the lower and the middle third. The ratio of 5.5:1 (XU:CU) received the lowest rating with 1.81 (out of possible 5.0). The results of the objective eye tracking analyses confirmed the subjective rating as the 2:1 ratio was fixated last amongst all other displayed ratios with 1.85 s whereas the 5.5:1 ratio had the shortest interval between image display and first stable eye fixation with 0.94 s. When analyzing the duration of stable eye fixations within the 6 s image display interval, it was revealed that the 5.5:1 ratio had the longest time with 3.38 s whereas the 2:1 ratio was viewed for the duration of 1.76 s and the 1:1 ratio was viewed for 1.51 s.

The results of the eye tracking analyses can be best understood when incorporating the concept of 'internal representation of beauty'. This concept is based on the socio-ethno-cultural development of beauty within each individual which is reflected in the individual's perception and rating of beauty. The internal representation of beauty is according to this concept a pre-defined and pre-conditioned status within each individual. This internal imprint of beauty is not static but can change during professional development, individual experiences or socio-cultural influences. Objects and features which fit or match into this 'internal standard' of beauty require less effort to be understood or processed by the individual. A beautiful object or feature would therefore attract less attention because it fits and passes the criteria of judgement of the observer. The present study provides evidence for this concept.

The most attractive position of the umbilicus as rated semi-quantitatively by the 58 study volunteers was the 2:1 ratio. This umbilical position was observed latest after the initial image

display with 1.85 s most likely because it did not capture the observer's attention, was matching the internal standard of beauty and was perceived therefore as aesthetically pleasing. This is also supported by the duration of stable eye fixations which was shorter when compared to the most unattractive umbilical position (5.5:1 ratio). On the contrary, the 5.5:1 ratio was rated as most unattractive most likely because it represents an un-natural umbilical position, captures the observers' attention, and is not perceived as aesthetically pleasing. Therefore, the time until the first stable eye fixation occurred was shortest after image display for the 5.5:1 ratio 0.94 s and had the longest duration of stable eye fixation within the 6 s image display interval 3.38 s. The short time to first fixation represents the mismatch between the presented visual stimulus which the observer needs to process and therefore is attracted to inspect it. This could be understood as the unconscious efforts of the individual to process and to understand the displayed image due to the fact that it deviates from the internal representation of beauty. This increased effort to match the displayed 5.5:1 ratio into an internal standard is also reflected by the increased duration of stable eye fixations during the total 6 s image display interval. These processes are unconscious and occur without voluntary control of the individual and can therefore best reflect of uncontrolled reactions toward beauty.

The presented results are somewhat in line with previous reports where the most aesthetic location of the umbilicus was determined to be the 1.618:1 ratio [11,12]. The difference between 1.618 and 2 could result from the different definition of the inferior boundary of the measurements performed: horizontal line between the iliac crest or pubic symphysis. Using the pubic symphysis would result in a greater ratio whereas the iliac crest line would result in a smaller ratio. From a surgical perspective, performing the distance measurements and calculating the 'golden ratio' would create both confusion and inaccuracy. Using the identified 2:1 ratio would allow for easy to perform measurements and increased accuracy. The distance between the visible infra-umbilical crease and the palpable xyphoid process would need to be divided into the three equidistant segments and the position of the umbilicus would be located between the caudal and the middle segment.

This study is not free of limitations: The 58 volunteers were altogether of Caucasian ethnicity as well as the selected stock image is the abdominal surface of a Caucasian young female. It could be speculated that the aesthetic perception would be different if the model and/or the volunteers would be of Asian or African-American ethnicity. This will need to be studied in future eye tracking based investigations where the race of the raters and the selected visual stimulus differ from the results presented herein. Another limitation could be the selection of a stock image (instead of a real image) which could create an observer bias. Precise variations of distance ratios are however difficult to obtain in a clinical scenario which could reduce the variety of visual stimuli presented. The selected umbilical ratios in this study revealed to be of statistically significant difference in their eye tracking parameter as the performed multi-variate analyses showed a statistically significant difference when compared across all eight umbilical ratios. This supports the utilized eye tracking technology in its ability to capture changes within the evaluated parameters. On a clinical note, the umbilicus cannot be readily moved across the abdominal surface. Depending on the surgical procedure, the range of placement is partly limited by the stalk attached to the abdominal wall, or – if applying the umbilical float technique or when performing a mini-abdominoplasty – by the inferior

displacement of the abdominal skin after removal of excessive tissue and inferior stretch to obtain wound closure in the infra-umbilical crease. Therefore, extreme umbilical positions, as assessed within this study, might not be within the range of clinical applicability. However, moderate changes are possible, and surgeons should be attentive to the impact of vertical umbilical positioning on the subjective and objective outcome parameters assessed within this study.

Conclusion

This investigation used eye tracking technology and semi-quantitative aesthetic rating to assess the most aesthetically pleasing position of the umbilicus. The findings revealed that the most attractive position of the umbilicus within the setting of the study was the 2:1 XU:UC ratio whereas the most unattractive ratio was the 5.5:1 XU:UC ratio if the ratio is determined between the skin projection of the xiphoid process and the umbilicus and the distance between the umbilicus and the infra-umbilical crease. Abdominoplasty procedures could rely on this easy to perform ratio by dividing the distance into thirds and using the boundary between the inferior and middle third as a clinically reliable landmark.

Disclosure statement

None of the other authors listed have any commercial associations or financial disclosures that might pose or create a conflict of interest with the methods applied or the results presented in this article.

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