

Aesthetic training concept during plastic surgery residency – Opportunity or risk?

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ABSTRACT

Background: Aesthetic surgery training renders to be challenging to acquire sufficient hands-on experience during residency. To resolve this problem, the “Munich Model” was established in our clinic: Senior residents perform aesthetic surgeries, supervised by an experienced plastic surgeon while patients benefit from reduced surgery costs. With this model, we hypothesize no significant differences in the postoperative outcome between procedures performed by residents and plastic surgeons.

Methods: Between August 2012 and December 2017, 481 aesthetic surgeries were included in this retrospective single-center study, of which 283 were performed by residents and 198 by plastic surgeons. Procedures included mastopexy, abdominoplasty, extremity lift, breast reduction, breast augmentation, facial surgery, aesthetic liposuction and lipedema liposuction. Postoperative outcomes were compared regarding surgery time, time of drain removal, inpatient length of stay, duration of wound healing, perioperative blood loss and occurrence of major (surgical revision needed) and minor complications (no surgery needed).

Results: We found no significant differences in aesthetic surgical procedures between residents and board-certified plastic surgeons in the outcome measures of surgery duration, time of drain removal, inpatient length of stay, perioperative blood loss and complication rate, including major and minor complications. Only the inpatient stay was prolonged in aesthetic liposuctions performed by residents.

Conclusion: This study demonstrates comparatively that supervised aesthetic surgeries at a university hospital utilizing the “Munich Model” widely meet the specialist surgeons’ standards.

1. Introduction

For the admission to the board examination, plastic surgery residents in Germany have to meet the requirement of 600 conducted plastic surgery procedures of all subspecialties, including 85 cases of aesthetic surgery [1,2]. Nevertheless, residents are facing

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Table 1

Demographic data and comorbidities of the procedure groups: (1) Mastopexy, (2) abdominoplasty, (3) extremity lift, (4) breast reduction, (5) breast augmentation, (6) facial surgery, (7) aesthetic liposuction and (8) lipedema liposuction. Abbreviations: PR: plastic surgery resident; PS: board-certified plastic surgeon. Values are given as counts or mean with standard deviation (\pm SD).

		Mastopexy		Abdominoplasty		Extremity lift		Breast reduction		Breast augmentation		Facial surgery		Aesth. Liposuction		Lipedema Liposuction		Total	
		78		98		39		68		63		74		23		38		481	
		PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS
Case numbers		47	31	71	27	23	16	37	31	35	28	8	30	46	28	16	7	283	198
Gender	<i>male</i>	–	–	13	9	2	2	–	–	–	–	2	6	2	5	–	–	19	22
	<i>female</i>	47	31	58	18	21	14	37	31	35	28	6	24	44	23	16	7	264	176
Age	<i>mean</i>	40	41	41	42	44	46	36	37	36	42	47	50	43	42	42	40	41	42
	\pm SD	16	15	14	14	14	9	15	17	15	14	16	18	12	16	11	12	14	14
Smoking	<i>Yes</i>	3	1	12	6	5	1	6	–	4	5	–	4	5	3	2	2	37	22
	<i>No</i>	44	30	59	21	18	15	31	31	31	23	8	26	41	25	14	5	246	176
Diabetes mellitus	<i>Yes</i>	4	3	7	3	1	3	2	1	3	–	–	2	4	2	1	–	22	14
	<i>No</i>	37	23	57	22	19	9	31	26	29	25	6	25	34	21	15	7	228	158
	<i>unknown</i>	6	5	7	2	3	4	4	4	3	3	2	3	8	5	–	–	33	26
Anti-coagulation	<i>Yes</i>	2	–	3	2	–	–	2	2	1	–	–	2	2	–	–	–	10	6
	<i>No</i>	39	26	61	23	20	12	31	25	31	25	6	25	37	23	16	7	241	166
	<i>unknown</i>	6	5	7	2	3	4	4	4	2	1	2	3	7	5	–	–	31	24
Follow-up	<i>mean</i>	80	63	127	93	67	67	97	74	106	80	208	33	64	85	74	76	103	71
	\pm SD	72	58	112	89	61	51	108	57	101	83	177	34	68	97	107	56	101	67

difficulties in reaching those case numbers, particularly of aesthetic surgery procedures which need to be conducted under the supervision of a board-certified plastic surgeon [3,4]. In fact, a study reported that 91% of German plastic surgery residents need additional training in aesthetic surgery [3]. After all, the physician's expertise and technical finesse correlate with hands-on experience [3,5,6], thus urging the need of a more comprehensive resident training. This has been progressively established in the United States, where training programs are standardized by the American Board of Plastic Surgery (ABPS) [7].

From another perspective, patients fear of an unsatisfactory outcome and high surgery costs and thus decide not to undergo surgery despite their interest in an aesthetic procedure [8,9]. In this context, it has been demonstrated that the complication rate in resident-conducted surgeries was nearly as low as in procedures performed by board-certified plastic surgeons [10,11]. Several studies suggested the necessity of resident-run aesthetic clinics which are widely popular in the United States in order to provide an adequate residency training [3,7,10,12–14]. With regard to this topic, we introduced in 2010 the “Munich Model” in our department to allow aesthetic surgery procedures to be performed by a senior resident under the supervision of a board-certified plastic surgeons, while patients benefit from reduced surgery costs. We previously examined our specific training program in 2013 and found that overall complication rates were not significantly different between surgical procedures performed by residents and board-certified plastic surgeons (5.5% and 4.4% respectively) [10]. Moreover, the quality of aesthetic procedures performed by residents in Germany was investigated in another study, which found a high patient satisfaction, but no comparison was made to board-certified plastic surgeons [12].

In this study, the differences between aesthetic surgeries performed by residents and plastic surgeons were investigated comparatively with regard to surgery duration, time of drain removal, inpatient length of stay, perioperative blood loss and complication rate. We hypothesize that there are no differences in terms of the postoperative outcome between both surgeon-groups and that supervised aesthetic surgeries performed by residents are safe for patients.

2. Materials and methods

2.1. Ethical approval

This monocentric, retrospective study was performed according to the approval of the ethics committee of our institute (reference number: 777/20-S-SR; approval date: 27/01/2021).

2.2. Study population

Between August 2012 and December 2017, 577 aesthetic procedures were performed on 453 patients in our department and 481 of these procedures with full records were included in this retrospective single-center study. 283 (58.8%) of the surgical procedures were performed by a supervised senior resident (above postgraduate year 4) and 198 (41.2%) by a board-certified plastic surgeon. Gender was distributed with 41 (8.5%) male and 440 (91.5%) female patients with a mean age of 41.43 ± 14.86 years (see patient demographics, Table 1). The surgeries were categorized into eight procedure groups: (1) Mastopexy, (2) abdominoplasty, (3) extremity lift (brachioplasty, thighplasty), (4) breast reduction, (5) breast-augmentation, (6) facial surgery (facelift, brow-lift, blepharoplasty, lipofilling), (7) aesthetic liposuction and (8) lipedema liposuction. Aesthetic liposuction and lipedema liposuction were analyzed separately, since lipedema liposuction is about pain reduction and achieving large fat volume reductions while aesthetic liposuction is about contouring, along with smaller volumes. Combined aesthetic procedures were performed in 131 surgeries (27.23%) and was distributed equally in the residents' group and board-certified plastic surgeons' group ($p = 0.14$). Combined procedures were categorized into both procedure groups. Comorbidities were evaluated regarding the status of smokers, diabetes and anticoagulation while group distribution of these factors was similar in the procedures of residents and plastic surgeons ($p = 0.57$, $p = 0.86$ and $p > 0.99$ respectively).

The mean follow-up for postsurgical complications was 86 days. Parameters of interest included surgery duration, time of drain removal, inpatient length of stay, perioperative blood loss and complication rate, including major and minor complications.

Retrospective data collection was performed from the records of surgical protocols, inpatient stay and follow-up examinations. Surgical time was measured in minutes using the incision-suture time. The time of drain removal, the inpatient length of stay and the duration of wound healing were measured in postoperative days (POD). Drain removal was performed when the volume was less than 30 mL per 24 h. The time of the last drain to be removed was considered in the analysis. Surgeries in an outpatient setting were excluded from inpatient length of stay. Completion of wound healing was defined by the POD of the presentation of clinically dry, irritation-free and closed wound conditions or the POD of the suture removal if no wound healing disorders were protocolled. Blood loss was assessed by the difference in hemoglobin (Hb) value in g/dL taken pre- and postoperatively (on the 1st POD). Complications were categorized into minor and major complications, based on the classification of Clavien-Dindo [15]: Minor complications were defined as adverse events that could be treated without surgical intervention (grade I and II complications), while major complications required surgical intervention, e.g., hemostasis, draining of hematoma/seroma, necrosectomy and wound revision surgery (grade III). Grade IV (life-threatening) and V (death) complications were not present in all of the cases and were therefore disregarded in major complications. Complications were identified in the time-frame of the follow-up and were not temporally limited. Types of complications are listed in Table 3. Wound healing disorders included prolonged wound healing with e.g., infection or dehiscence.

2.3. Statistics

For statistical analysis, we used the GraphPad Prism 9 Software. Numerical data sets were analyzed with student's t-test. Values were expressed as mean with standard deviation (\pm SD). When comparing datasets with categorical variables, the Fisher's exact test was used. A value of $p < 0.05$ was considered statistically significant (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$).

3. Results

3.1. Analysis of the surgery duration

For the comparative analysis of the surgery duration, we used the incision-suture time. Here, we found no significant differences between the procedures performed by plastic surgery residents (PR) and board-certified plastic surgeons (PS) in all of the procedure groups and total procedures (Fig. 1). On average, the incision-suture time in PR was 177 min and in PS 161 min ($p = 0.08$).

3.2. Analysis of the time of drain removal

Drains were used at a high percentage in the procedures: In 87% of the procedures performed by PR and in 89% of the procedures of board-certified PS (Table 2). The data for aesthetic facial surgery, aesthetic liposuction and lipedema liposuction were not included

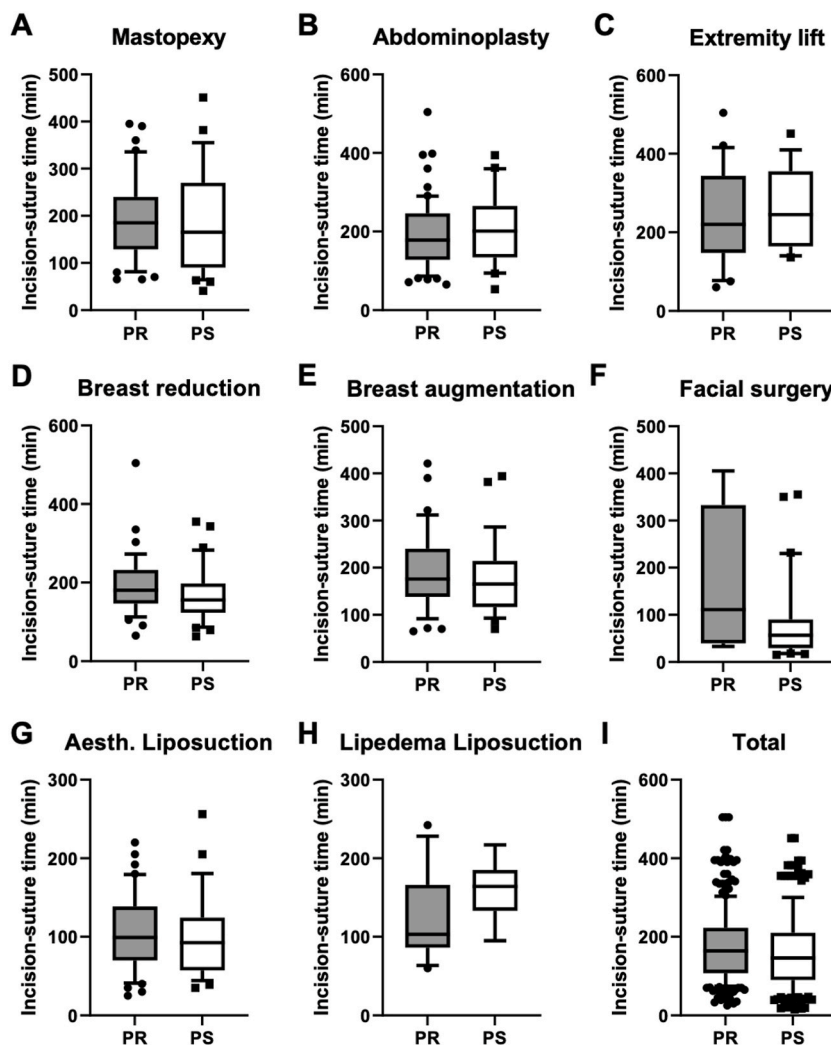


Fig. 1. Incision-suture time of the procedure groups (A–H) and total procedures (I). Comparison of incision-suture time in minutes (min) between procedures performed by plastic surgery residents (PR) and board-certified plastic surgeons (PS). There are no significant differences regarding incision-suture times between PR and PS in all the procedure groups and total procedures ($p > 0.05$). Boxplots displaying the 90/10 percentile at the whiskers, the 75/25 percentiles at the boxes and the median in the center line. The dots are outliers. Student's t-test.

since drains were not used. Regarding the time of drain removal, there were no differences between PR and PS in all procedure groups ($p > 0.05$) (Fig. 2). In all of the procedures, mean time of drain removal was on the 3.4th postoperative day (POD) in PR and 3.1st POD in PS ($p = 0.49$).

3.3. Analysis of the inpatient length of stay

The inpatient length of stay for all types of aesthetic surgeries was overall 3.9 ± 3.1 POD in PR and 3.6 ± 2.7 POD in PS ($p = 0.18$) (Fig. 3). Only aesthetic liposuction showed a significant prolongation of hospital stay in PR compared to PS (2.5 vs 1.7 POD, $p = 0.02$) (Fig. 3G). In the remaining procedure groups, there were no significant differences between both groups ($p > 0.05$).

3.4. Analysis of the duration of wound healing

Completion of wound healing was determined by the presentation of clinically dry, irritation-free and closed wound conditions. Here, we found no significant differences between the procedures performed by PR and PS in all of the procedure groups and total procedures ($p > 0.05$) (Fig. 4). Overall, wound healing was documented as completed on the 28th \pm 27.8 POD in PR and on the 25th \pm 19.3 POD in PS ($p = 0.29$).

3.5. Analysis of the perioperative blood loss

The perioperative blood loss was assessed by comparing the pre- and postoperative hemoglobin (Hb) concentration. The results showed no significant differences regarding the hemoglobin drop between procedures performed by PR and PS in all of the procedure groups and in total procedures ($p > 0.05$) (Fig. 5). Overall, perioperative blood loss in PR was 2.4 ± 1.6 g/dL Hb and in PS 2.6 ± 1.3 g/dL Hb ($p = 0.44$). The group "aesthetic liposuction" and "facial surgery" were excluded in this analysis, since postoperative blood was not drawn regularly.

3.6. Analysis of the complications

With regard to the complication rate, there was no difference determined between procedures performed by PR and PS in all of the procedure groups and in total procedures ($p > 0.05$) (Table 3). The odds-ratios for an occurrence of a complication in PR versus PS ranged from 0.4 to 3.5, with an overall odds ratio of 1.2 (20.1% versus 17.7% complication rate respectively). In the further step of categorizing these complications into major (surgery needed) and minor complications (no surgery needed), there were as well no difference between the procedures performed by PR and PS ($p > 0.05$). The odds-ratios for an occurrence of a major complication in PR versus PS ranged from 0.3 to 2.6, with an overall ratio of 1.2 (7.4% versus 6.1% major complication rate respectively). For minor complications, the odds-ratios for an occurrence of a minor complication in PR versus PS ranged from 0.4 to 2.6, with an overall ratio of 1.1 (12.7% versus 11.6% minor complication rate respectively). Finally, we differentiated the complications into hematoma, wound healing disorder and skin necrosis (Table 3). Wound healing disorders represented the most common complication in both groups with 46 cases (80% of total complications) in PR and in 23 cases (66% of total complications) in PS.

4. Discussion

The number of aesthetic procedures has been increasing worldwide, urging the need for improvements in aesthetic surgery training during plastic surgery residency [16]. In Germany, a study by Momeni et al. showed that only 12% of the plastic surgery residents received an adequate aesthetic training and only 56% of the senior residents (above postgraduate year 4) have performed a maximum of ten aesthetic surgeries in their residency [3]. Indeed, studies have found that a minimum of 10–20 performed procedures are required for sufficient confidence in terms of independent practice [3,6]. Deficits in aesthetic training have been also recognized in the United States by the American Board of Plastic Surgery (ABPS) and the Accreditation Council for Graduation Medical Education (ACGME), which led to standardizations in the resident training curriculum, including increasing the requirement of aesthetic cases, adding an additional year to residency training and introducing resident-run aesthetic clinics [7]. The latter represents a method of

Table 2

Use of drains in the procedure groups: (1) Mastopexy, (2) abdominoplasty, (3) extremity lift, (4) breast reduction, (5) breast augmentation. Abbreviations: PR: plastic surgery resident; PS: board-certified plastic surgeon.

	Mastopexy		Abdominoplasty		Extremity lift		Breast reduction		Breast augmentation		Total		
	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	
	Case numbers	47	31	71	27	23	16	37	31	35	28	213	133
Drains (% of case numbers)	<i>Yes</i>	32	24	65	24	16	13	35	30	32	24	186	118
		(68%)	(77%)	(92%)	(89%)	(70%)	(81%)	(95%)	(97%)	(91%)	(86%)	(87%)	(89%)
	<i>No</i>	15	7	6 (8%)	3	7	3	2 (5%)	1 (3%)	3 (9%)	4	96	80
		(32%)	(23%)	(11%)	(11%)	(30%)	(19%)			(14%)	(13%)	(11%)	

Table 3

Complications in the procedure groups: (1) Mastopexy, (2) abdominoplasty, (3) extremity lift, (4) breast reduction, (5) breast augmentation, (6) facial surgery, (7) aesthetic liposuction and (8) lipedema liposuction. Abbreviations: PR: plastic surgery resident; PS: board-certified plastic surgeon. Values are given as counts and % of case numbers or total complications. Fisher's exact test. Odds ratio of PR over PS.

	Mastopexy		Abdominoplasty		Extremity lift		Breast reduction		Breast augmentation		Facial surgery		Aesth. Liposuction		Lipedema Liposuction		Total	
	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS	PR	PS
Case numbers	47	31	71	27	23	16	37	31	35	28	8	30	46	28	16	7	283	198
Total complications (% of case numbers)	3 (6.38%)	5 (16.13%)	22 (30.99%)	11 (40.74%)	6 (26.09%)	3 (18.75%)	15 (40.54%)	8 (25.81%)	4 (11.43%)	1 (3.57%)	1 (12.50%)	–	4 (8.70%)	1 (3.57%)	2 (12.50%)	1 (14.29%)	57 (20.14%)	35 (17.68%)
p value/odds ratio	0.25/0.35		0.47/0.65		0.71/1.53		0.30/1.96		0.37/3.48		0.21/–		0.64/2.57		>0.99/0.86		0.56/1.17	
Major complications (% of case numbers)	1 (2.13%)	2 (6.45%)	11 (15.49%)	5 (18.52%)	2 (8.70%)	1 (6.25%)	5 (13.51%)	2 (6.45%)	1 (2.86%)	1 (3.57%)	1 (12.50%)	0	0	0	0	0	21 (7.42%)	12 (6.06%)
p value/odds ratio	0.56/0.32		0.76/0.81		>0.99/1.43		0.44/2.27		>0.99/0.80		0.21/–		–/–		–/–		0.59/1.24	
Minor complications (% of case numbers)	2 (4.26%)	3 (9.68%)	11 (15.49%)	6 (22.22%)	4 (17.39%)	2 (12.50%)	10 (27.03%)	6 (19.35%)	3 (8.57%)	0	0	0	4 (8.70%)	1 (3.57%)	2 (12.50%)	1 (14.29%)	36 (12.72%)	23 (11.62%)
p value/odds ratio	0.38/0.41		0.55/0.64		>0.99/1.47		0.57/1.54		0.25/–		–/–		0.64/2.57		>0.99/0.86		0.78/1.11	
Hematoma (% of total complications)	0	2 (40%)	2 (9%)	0	1 (17%)	0	0	2 (25%)	1 (25%)	0	0	0	1 (25%)	0	1 (50%)	0	6 (11%)	4 (11%)
Wound healing disorder (% of total complications)	3 (100%)	3 (60%)	19 (86%)	10 (91%)	5 (83%)	2 (67%)	12 (80%)	6 (75%)	3 (75%)	1 (100%)	1 (100%)	0	3 (75%)	1 (100%)	0	0	46 (80%)	23 (66%)
Skin necrosis (% of total complications)	0	0	1 (5%)	1 (9%)	0	1 (33%)	3 (20%)	0	0	0	0	0	0	0	1 (50%)	1 (100%)	5 (9%)	3 (9%)

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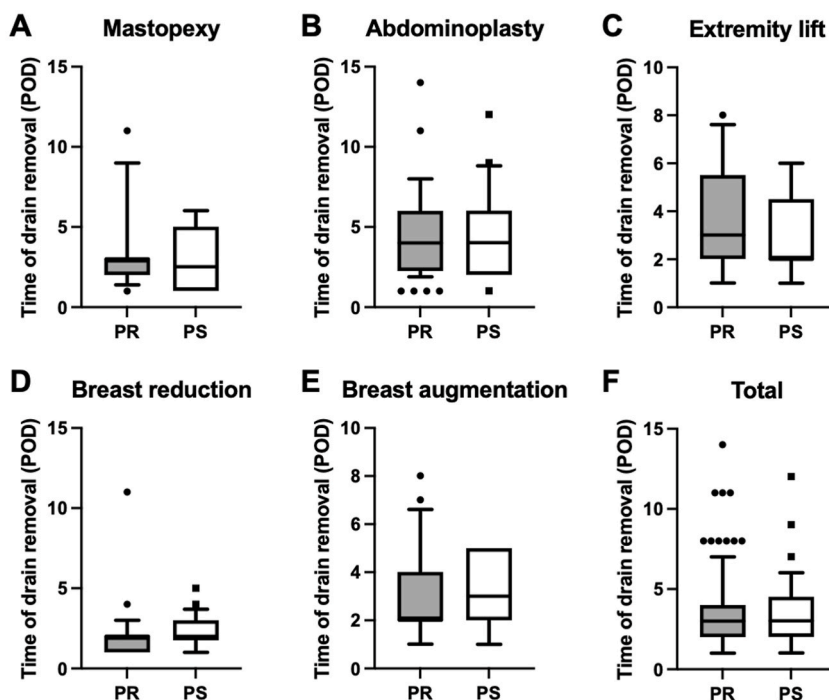


Fig. 2. Time of drain removal of the procedure groups (A–E) and total procedures (F). Comparison of time of drain removal in postoperative days (POD) between procedures performed by plastic surgery residents (PR) and board-certified plastic surgeons (PS). There were no significant differences regarding time of drain removal between PR and PS in all the procedure groups and total procedures ($p > 0.05$). Boxplots displaying the 90/10 percentile at the whiskers, the 75/25 percentiles at the boxes and the median in the center line. The dots are outliers. Student's t-test.

residency training with the purpose to develop and improve practical aesthetic skills from the first patient contact to the operating theatre under appropriate supervision. Our clinic adopted this strategy of aesthetic training with the “Munich Model” since 2010, aiming at the highest safety for patients during surgical procedures. Therefore, potential risks in surgical procedures performed by residents need to be constantly evaluated. The results of this retrospective study of over 64 months demonstrated no significant differences in aesthetic surgical procedures between residents and board-certified plastic surgeons in the outcome measures of duration of surgery, inpatient length of stay, time of drain removal, perioperative blood loss and complication rate, including major complications (surgical revision needed) and minor complications (no surgery needed). Only the hospital stay was prolonged after resident-performed aesthetic liposuction. Overall, we were able to demonstrate that supervised resident-performed aesthetic surgeries are as safe as procedures performed by board-certified plastic surgeons.

The importance of time-efficient surgeries was illustrated in several studies, which found that prolonged surgical procedures were associated with higher risks of complications, e.g., wound healing disorders, erythema, necrosis, seroma and hematoma [17,18]. Additionally, its economic relevance also involves the costs of the operating theatre along with the anesthesiologist and furthermore the costs of treating possible complications [17,18]. In this study, our analysis of the incision-suture time did not show an increase of surgery duration in the aesthetic procedures performed by residents compared to board-certified plastic surgeons (Fig. 1). In this regard, the topic of a possible prolongation of resident involvement in aesthetic surgeries is highly discussed: Peterson et al. hypothesized that residents would increase the operative time due to teaching and training provided by plastic surgery specialists [19]. This effect however could not be confirmed and the results are therefore consistent with our study. This is in contrast to the results of a much larger study by Malyar et al. who used 9638 cases to demonstrate the influence of a resident on the duration of surgery in body contouring procedures [13]: The operation times were significantly increased by residents compared to board-certified plastic surgeons. Interestingly, residents of higher postgraduate year appeared to exert less prolongation of surgery time. This supports the results of our study, in which only senior residents in their final years were involved in our training model. In this regard, an additional comparison to aesthetic procedures performed by board-certified plastic surgeons without residents, e.g., in private practices, would be of high interest to analyze the actual involvement of resident participation.

The time of drain removal provides conclusions about the operative skills such as hemostasis and dead space management and may reveal if patients exhibit a postoperative seroma [20]. Here, we found no difference regarding the time of drain removal between aesthetic procedures performed by residents and board-certified plastic surgeons (Fig. 2). In another aspect, the issue of prolonged drains has been described with patient discomfort, occurrence of scarring, increased costs due to regular check-ups and increased risk of retrograde infection [20,21]. Nonetheless, in order to prevent drain-associated drawbacks, proper time of drain removal is reported to be critical [22]. In a study by Phillips et al. which compared the time of drain removal in breast reconstruction surgeries, 86% of the 650 surveyed plastic surgeons removed the drains when the volume is less than 30 mL per 24 h [22]. This is consistent with our

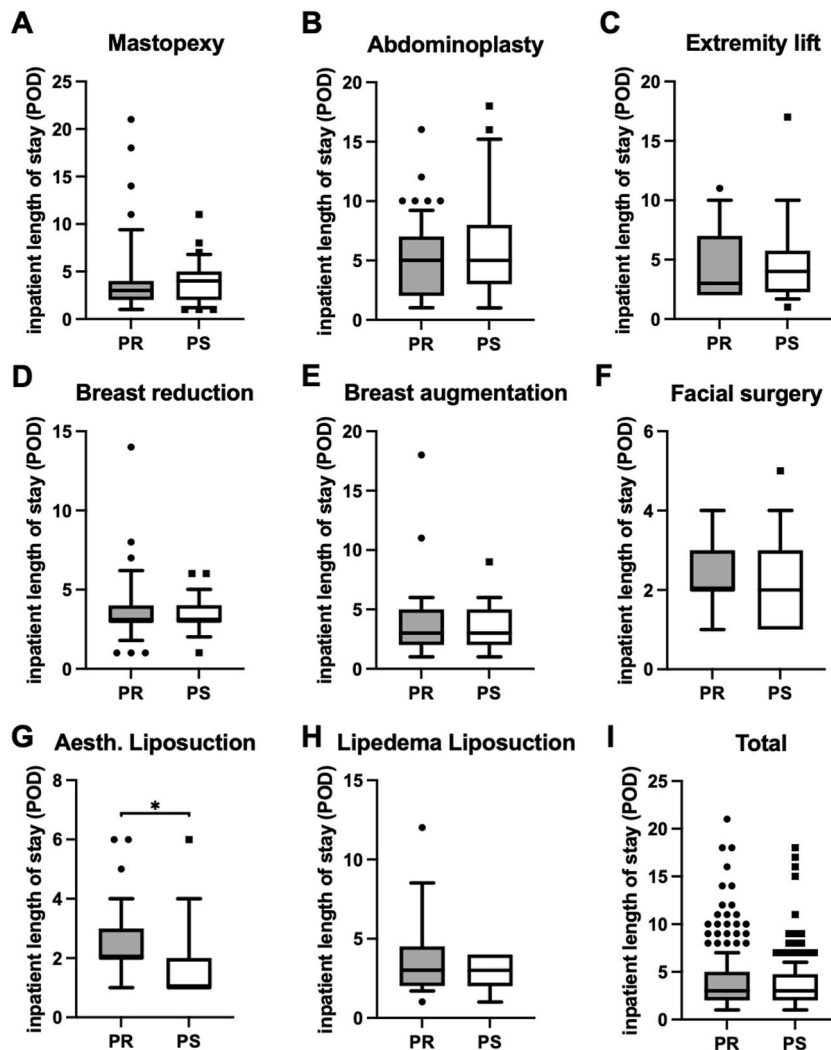


Fig. 3. Inpatient length of stay of the procedure groups (A–H) and total procedures (I). Comparison of inpatient length of stay in postoperative days (POD) between procedures performed by plastic surgery residents (PR) and board-certified plastic surgeons (PS). In terms of aesthetic liposuction, there was a prolongation of inpatient length of stay in the PR-group ($p = 0.02$). There were no significant differences in the other procedure groups and in total procedures ($p > 0.05$). Boxplots displaying the 90/10 percentile at the whiskers, the 75/25 percentiles at the boxes and the median in the center line. The dots are outliers. Student's t-test. * = $p < 0.05$.

management across all surgical procedures which increases the reliability of the comparisons in this study.

Among other factors, drain duration may influence the inpatient length of stay. In those procedures where drains were used (mastopexy, abdominoplasty, extremity lift, breast reduction and breast augmentation, Fig. 3) and not used (facial surgery and lipedema liposuction), there were no differences regarding the length of hospital stay between both groups. Interestingly, inpatient stay of aesthetic liposuctions was prolonged significantly by 0.7 days in the residents procedure group (2.5 d vs 1.7 d, Fig. 3G). This slight prolongation could be explained by the higher risk of a minor complication in resident surgeries (odds ratio 2.5), although major complications were absent and the occurrence of minor complications was not significantly increased (Table 3). In this context, Malyar et al. investigated the effect of resident involvement in breast reduction and body contouring procedures on the patient's hospital stay. The authors demonstrated a significant prolongation of hospital stay of 0.7 days (1.4 d vs 0.7 d) in the overall resident group, but not in a subgroup consisting of senior residents only [13]. This is in accordance to the results of our study. On account of its relevance, it has been recognized that with longer inpatient length of stay, the possibility of complications rises, e.g., the risk of nosocomial infection, immobilization-related diseases and psychological decline [23]. In addition, economic factors also play an important role, as the costs for the patient, the hospital and/or the health care system increase with prolonged inpatient stay [24].

Regularly performed examinations of the wound represent an integral part of postoperative patient care and minimizes potential complications, such as surgical-site infections, wound dehiscence and hematoma [25]. In the case of aesthetic surgery, wound edges are usually clean and smooth, thus can be easily adapted and heal by primary intention [26]. The duration of wound healing may

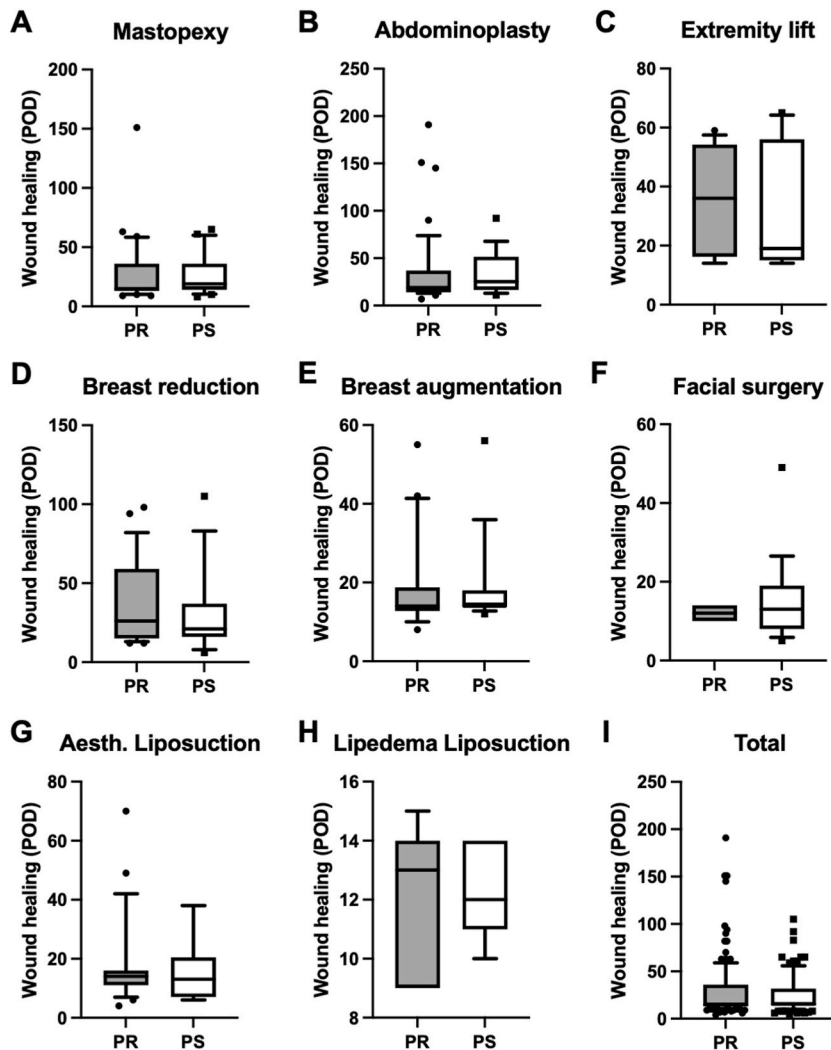


Fig. 4. Duration of wound healing of the procedure groups (A–H) and total procedures (I). Comparison of duration of wound healing in postoperative days (POD) between procedures performed by plastic surgery residents (PR) and board-certified plastic surgeons (PS). There were no significant differences regarding duration of wound healing between PR and PS in all the procedure groups and total procedures ($p > 0.05$). Boxplots displaying the 90/10 percentile at the whiskers, the 75/25 percentiles at the boxes, and the median in the center line. The dots are outliers. Student’s t-test.

depend on many different factors: Pre-existing conditions and therapies, e.g., diabetes mellitus, malignancies, radiotherapy, corticosteroids, smoking or elderly patients have an increased risk of prolonged wound healing or even the occurrence of complications [27]. The completion of wound healing was investigated in this study and no significant delays in either group of residents or plastic surgeons have been determined (Fig. 4). In particular, wounds were healed in the mean of 28 days in the resident’s group and 25 days in the plastic surgeon’s group.

Postoperative anemia can increase patient morbidity and mortality, especially if patients have pre-existing cardiovascular diseases [28]. The intraoperative blood loss is influenced by the surgical technique, therefore, the perioperative drop of hemoglobin between procedures of residents and board-certified plastic surgeons was evaluated. We found no difference between both groups (Hb drop residents: 2.4 g/dL and plastic surgeons 2.6 g/dL, Fig. 5) which indicates no increased postoperative risk of anemia. This result most probably derived from adequate hemostasis during the operation which is in accordance to the time of drain removal discussed before. Nonetheless, hemoglobin measurements are also easily influenced by intravenous fluid substitution which certainly had a compound effect on this parameter.

Detecting and treating complications is an essential part of surgical follow-up and possibly one of the greatest concerns of patients and surgeons. Complications allow conclusions to be drawn about the quality and safety of the operation. Accordingly, prior to any surgical procedure, the chance of benefits and harms to the patient is carefully evaluated in order to keep the complication rate as low as possible. Co-morbidities were analyzed in this study with regard to the status of smokers, diabetes and anticoagulation, while group

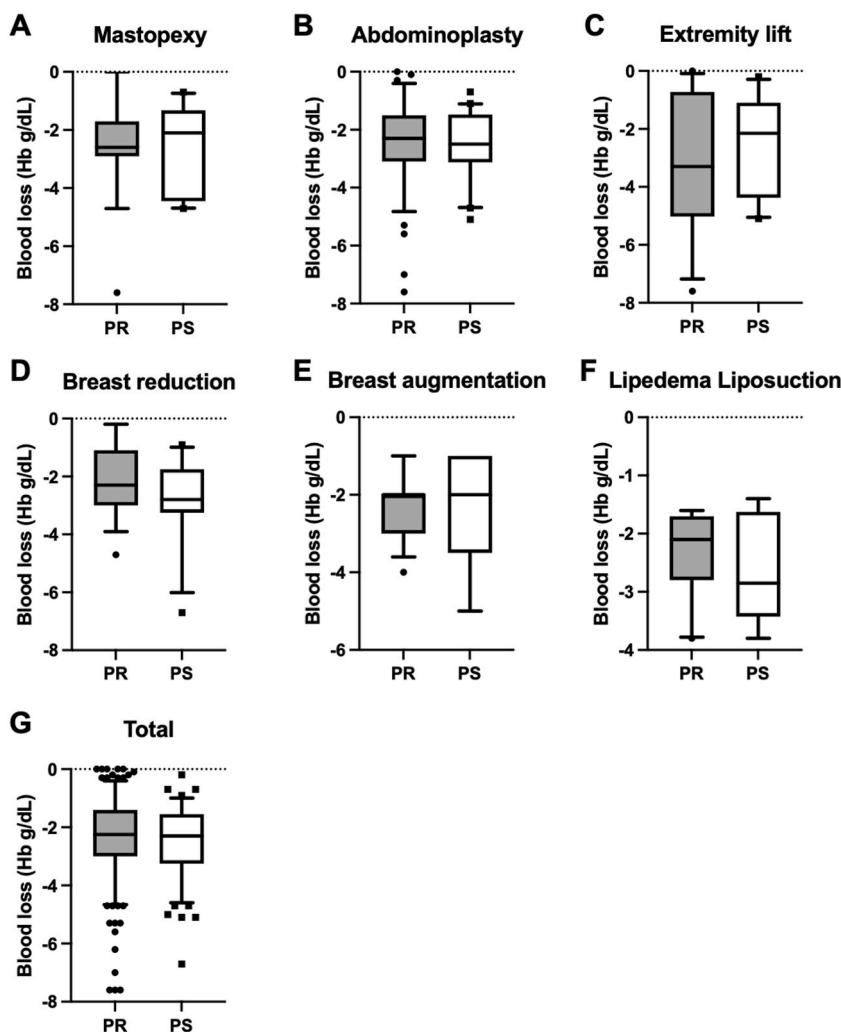


Fig. 5. Perioperative blood loss of the procedure groups (A–F) and total procedures (G). Comparison of the perioperative blood loss measured in hemoglobin (Hb) g/dL between procedures performed by plastic surgery residents (PR) and board-certified plastic surgeons (PS). There were no significant differences regarding blood loss between PR and PS in all the procedure groups and total procedures ($p > 0.05$). Boxplots displaying the 90/10 percentile at the whiskers, the 75/25 percentiles at the boxes, and the median in the center line. The dots are outliers. Student's t-test.

distribution of these factors was similar in the procedures of residents and plastic surgeons (Table 1). Certainly, the previous analysis parameters (surgery length, time of drain removal, inpatient length of stay, time of wound healing and blood loss) reflect indirectly the rate of complications. Thus, there is no surprise that complications, regardless of major or minor, are not significantly elevated in the resident's group compared to the board-certified plastic surgeon's group (Table 3). Major complications which required surgical revision was 7.4% in residents and 6.1% in plastic surgeons, minor complications treated non-surgically was as a low as 12.7% and 11.6% respectively. Of all complications, wound healing disorders represented the most with 80% and 66% respectively. Comparing the resident's complication rate with other clinics of similar aesthetic procedures performed: Pyle et al. reported of 14.4% major complications and 7.5% minor complications (same definitions of complications to our study) [14], which can be considered in the range of our complication rates. Koulaxouzidis et al. reported of 6.3% major complications and 3.4% minor complications [12]. However, the definitions of major and minor complications were different, i.e., minor surgical revisions were not included in major complications and complications over the time frame of 30 days were excluded [12]. Indeed, the nomenclature of complications has been heterogenous in the literature resulting in difficulties for study comparisons [29,30]. Thus, a more standardized and differentiated classification of complications in aesthetic surgeries is required.

One limitation of our study is the retrospective study design. Thus, minor complications, time of drain removal and completion of wound healing are highly dependent on the documentation and subjective assessment of clinical findings by the responsible physician. Additionally, patient satisfaction with the aesthetic result was not recorded in the patient's files, therefore this parameter could not be included in this retrospective study. In fact, there was no significant difference in the total number of aesthetic surgical revisions (e.g., dog ear revision, scar revision, which are not counted as complications) between the two groups (16% for PR and 17% for PS, $p >$

0.05), indicating a comparable patient satisfaction. In this regard, a future prospective study with a standardized patient satisfaction questionnaire is required. Furthermore, combined aesthetic procedures were included with 27.23% of all cases. Although the distribution was similar in the resident's and board-certified plastic surgeon's group, the individual combined surgeries are different and thus the incision-suture time comparisons have to be considered under this bias. Finally, difficult aesthetic surgeries are not part of the training program and are instead reserved for the specialists (PS). Thus, the outcomes might also be affected by the varying levels of difficulty which should be considered as bias.

5. Conclusions

This study demonstrates that supervised aesthetic surgery procedures at a university hospital utilizing the "Munich model" meets board-certified plastic surgeon's standards and is a safe alternative for patients. Additionally, by reducing surgery costs, the procedures become affordable for many patients. Simultaneously, residents can benefit from hands-on experience and aesthetic training during supervised surgeries.

Author contribution statement

Philipp Moog and Haydar Kükrek: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jun Jiang and Daniel Schmauss: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Lara Buchner: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Inessa Suhova and Hans-Günther Machens: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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Institutional review board statement

This monocentric, retrospective study was performed according to the approval of the ethics committee of our institute (reference number: 777/20-S-SR; approval date: 27/01/2021).

Informed consent statement

Not applicable.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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