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REVIEW ARTICLE

Comparative Efficacy and Safety of Laparoscopic Greater Curvature Plication and Laparoscopic Sleeve Gastrectomy: A Meta-analysis

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Abstract Laparoscopic greater curvature plication (LGCP) is considered to have evolved from less invasive laparoscopic sleeve gastrectomy (LSG). In the present meta-analysis, we compared these two procedures in terms of efficacy and safety. We searched PubMed, Embase, and the Cochrane Library from database inception until April 2015. Excess weight loss (%EWL), resolution of obesity-related comorbidities, adverse events, operation time, and postoperative hospital stay were evaluated using the software Review Manager 5.3. The following four studies were eligible for inclusion: one randomized controlled trial and three non-randomized controlled trials involving 299 patients. Our meta-analysis demonstrated a significantly greater %EWL after LSG than LGCP at the follow-up time points of 3 months ($Z=2.26$, $p=0.02$), 6 months ($Z=4.49$, $p<0.00001$), and 12 months ($Z=6.99$, $p<0.00001$). The difference in the resolution of diabetes mellitus between these two approaches did not reach statistical significance ($p=0.66$). According to the pooled data, LGCP was associated with more adverse events than was LSG ($p=0.01$). The operation time ($p=0.54$) and postoperative hospital stay ($p=0.44$) were comparable between the two groups. LGCP is inferior to LSG not only in terms of providing effective weight loss but also in terms of safety.

Keywords Laparoscopic greater curvature plication · Laparoscopic sleeve gastrectomy · Bariatric surgery · Obesity · Meta-analysis

Introduction

Obesity is an emerging worldwide phenomenon. In 2005, at least 400 million adults were obese globally according to the projection made by the World Health Organization [1]. Current data indicate that more than one-third of the US population is obese (body mass index>30 kg/m^2), while more than half of the population is overweight (body mass index>25 kg/m^2) [2]. Excess weight, especially the state of obesity, is an independent and remarkable risk factor for type 2 diabetes mellitus [3], which results in serious microvascular and macrovascular problems in the long term. Obesity is also cited as a contributing factor to several comorbidities, including certain types of malignant tumors and severe heart disease [4]. As a result, obesity is now generally considered to be one of the major causes of preventable death.

Bariatric surgery has increased in popularity in recent years because of its ability to achieve a greater decrease in body weight and higher remission of obesity-related comorbidities compared with nonsurgical interventions [5]. The following three types of weight loss surgery are widely performed: laparoscopic adjustable gastric banding, laparoscopic Roux-en-Y gastric bypass, and laparoscopic sleeve gastrectomy (LSG). Among these approaches, LSG has the advantages of excellent early to long-term weight loss results, comorbidity resolution, and low postoperative complication rates [6–8]; it is therefore the most frequently used technique in the Asia-Pacific region, the USA, and Canada [9]. This surgery involves resection of the greater curvature and results in gastric tube formation, reducing the gastric volume to about 100 mL,

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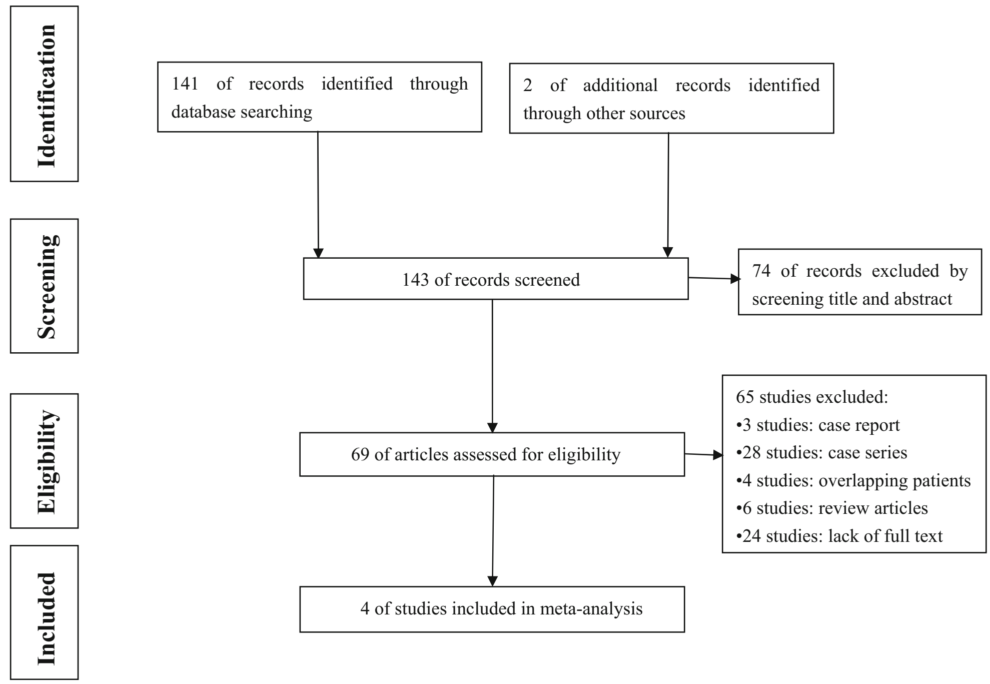
Fig. 1 Study selection diagram



which is easy to fill and induces less food intake. However, severe complications such as staple line leakage associated with the long staple line have been reported [10].

Laparoscopic greater curvature plication (LGCP) is a novel restrictive bariatric surgery. It was proposed in 2007 by Talebpour et al. [11] and has been gaining prominence worldwide. In this technique, the stomach is reshaped to a narrow tube by plication of the greater curvature, similar to sleeve gastrectomy. LGCP has the potential advantage of reversibility and safety without resecting any part of the stomach, and it is likely more cost effective because there is no requirement for expensive surgical staplers. However, this technique is still in development and lacks enough data with which to assess its safety and effectiveness. Thus, we performed a meta-analysis to compare the efficacy and safety of LGCP versus LSG, aiming to quantitatively evaluate the advantages of LGCP.

Materials and Methods

Publication Search

We searched PubMed, Embase, and the Cochrane Library for all relevant English-language full-text literature published from database inception to April 2015. The search terms were as follows: plication or imbrication or gastroplication, sleeve

Table 1 Baseline characteristics of included studies. *LGCP* laparoscopic greater curvature plicationis, *LSG* laparoscopic sleeve gastrectomy, *SD* standard deviation, *NR* not reported, *RCT* randomized controlled trial

References	Study type	Interventions	No of patients	Female *N* (%)	Quality score	Age (years) mean (SD)	Baseline BMI (kg/m2) mean (SD)	Major complications *N* (%)	Reoperations *N* (%)
Daunia Verdi, 2015, Italy [13]	Retrospective	LGCP	45	39 (86.7)	8[a]	37.8 (11.45)	40.65 (4.99)	13 (28.9)	27 (60.0)
		LSG	45	39 (86.7)		40 (9.14)	41 (5.07)	4 (8.8)	4 (8.8)
Dijian Shen 2013, China [14]	Prospective	LGCP	19	14 (73.7)	8[a]	33.9 (5.7)	37.3 (4.3)	0 (0)	NR
		LSG	20	13 (65.0)		34.2 (6.3)	38.4 (6.3)	0 (0)	NR
Tamer N. Abdelbaki, 2014, Egypt [15]	Retrospective	LGCP	62	50 (81 %)	8[a]	34.45 (10.7)	41.62 (7.1)	6 (9.7)	2 (3.2)
		LSG	78	57 (73 %)		31.77 (9.2)	48.27 (6.9)	4 (5.1)	2 (2.6)
Sunil Sharma, 2014, India [16]	RCT	LGCP	15	6 (40.0)	4[b]	40.5	44.7	2 (13.3)	2 (13.3)
		LSG	15	6 (40.0)		39.9	44.0	0 (0)	0 (0)

[a] Newcastle-Ottawa quality assessment scale score

[b] Jadad's rating scale score

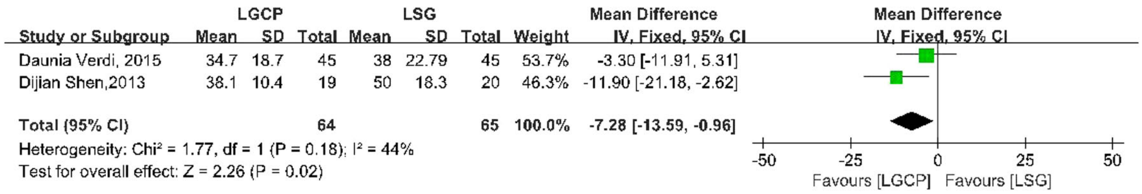


Fig. 2 Forest plot of comparison between LGCP and LSG in %EWL at 3 months postoperatively

or vertical, and laparoscopy or laparoscopic. All relevant articles were also searched manually to identify other related studies.

Selection Criteria

Each article was critically reviewed by two authors (Y.T. and S.T.) according to the following inclusion criteria: (1) study design: any type of comparative study, (2) study population: patients undergoing LGCP or LSG, (3) intervention: comparison between LGCP and LSG, (4) outcomes: inclusion of information on efficacy or safety, (5) availability of the full text, and (6) publication in English. The exclusion criteria included overlapping data, case series, case reports, and conference abstracts.

Data Extraction

Two reviewers (Y.T. and S.T.) independently extracted the following data from each study: excess weight loss (%EWL), resolution of obesity-related comorbidities, adverse events, operation time, and postoperative hospital stay. All discrepancies were resolved by the senior author (S.H.). We contacted the corresponding authors to obtain unreported data, but no additional information was provided.

Quality Assessment

We used the revised Jadad rating scale to evaluate the methodological quality of randomized control trials (RCTs), with high-quality studies scoring 4–7 points. The Newcastle-Ottawa quality assessment scale was also applied to evaluate the quality of non-RCTs, which were allocated to either level 1 (0–5 points) or level 2 (6–9 points).

Statistical Analysis

Review Manger software (Revman version 5.3) was used for statistical analysis. The %EWL, operation time, and postoperative hospital stay were compared using weighted mean differences. The odds ratios were applied to compare resolution of obesity-related comorbidities and adverse events. A p value of <0.05 was regarded as statistically significant. The χ^2 and I^2 statistics were adopted to analyze the statistical heterogeneity across the included studies. An I^2 value of 25 and 75 % indicated low and high levels of heterogeneity, respectively [12]. We used fixed-effect models or random-effect models for comparisons. We considered statistically significant heterogeneity to be present at a p value of <0.10 with the use of a random-effects model.

Results

Study Characteristics

The search of electronic databases and relevant studies initially identified 143 articles. Following article selection based on the criteria as described, we analyzed data from four studies (one RCT, two retrospective studies, and one prospective study) (Fig. 1) involving 299 patients, 141 in the LGCP group and 158 in the LSG group.

The baseline demographics and quality assessment of these four studies are shown in Table 1. The studies were conducted in Italy, China, Egypt, and India, respectively. The quality of all included studies was satisfactory.

Calculation of %EWL

Weight loss was measured by %EWL±standard deviation, defined as (weight loss/excess weight)×100 [17]. Our meta-

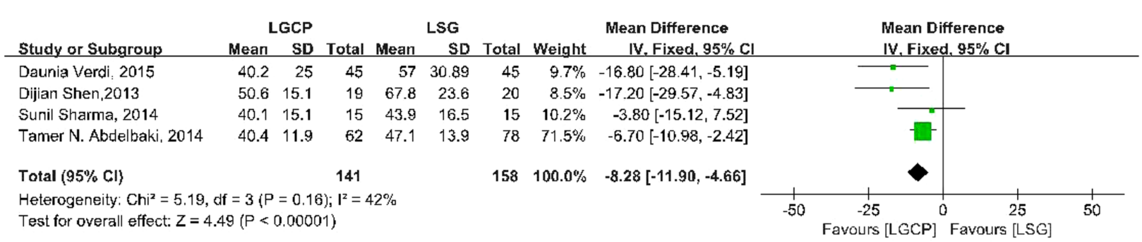


Fig. 3 Forest plot of comparison between LGCP and LSG in %EWL at 6 months postoperatively

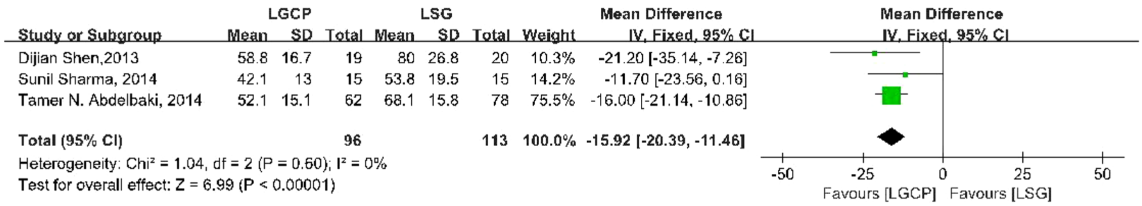


Fig. 4 Forest plot of comparison between LGCP and LSG in %EWL at 12 months postoperatively

analysis demonstrated a significantly greater %EWL after LSG than LGCP at the follow-up time points of 3 months (Z=2.26, p=0.02) (Fig. 2), 6 months (Z=4.49, p<0.00001) (Fig. 3), and 12 months (Z=6.99, p<0.00001) (Fig. 4). No significant differences were found in these comparisons when the fixed-effects models were applied. The I^2 (p value) at 3, 6, and 12 months were 44 (0.18), 42 (0.16), and 0 % (0.60), respectively.

Resolution of Obesity-Related Comorbidities

Two studies provided information about resolution of obesity-related comorbidities. We resorted to a fixed-effects model for diabetes mellitus because there was no remarkable heterogeneity. However, no significant difference was found between these two procedures (Z=0.43, p=0.66) (Fig. 5).

Adverse Events

Adverse events defined as postoperative major morbidities were pooled from four studies. The fixed-effects model was used in this meta-analyses for homogeneity of the included studies. Consequently, LGCP was associated with more major complications than LSG (Z=2.45, p=0.01) (Fig. 6).

Operation Time

Three studies reported the operative time. There was significant heterogeneity among the studies (I^2=91 %, p<0.0001). However, no statistical difference was found when the random-effects model was used (Z=0.61, p=0.54) (Fig. 7).

Postoperative Hospital Stay

There was no significant difference in the postoperative hospital stay among the studies (Z=0.77, p=0.44) (Fig. 8), with remarkable heterogeneity (I^2=66 %, p=0.09).

Discussion

Sleeve gastrectomy was initially conceived as a bridging procedure to biliopancreatic diversion with duodenal switch for super-obese patients with comorbidities [18]. Regan et al. [19] proposed a two-stage laparoscopic Roux-en-Y gastric bypass in which LSG was performed as a primary intervention in high-risk patients. Following that report, LSG rapidly became an independent bariatric procedure because of its effectiveness and simplicity. Additionally, the data on the short- and mid-term outcomes of LSG are very promising [20]. One systematic review of 16 studies with a follow-up of more than 5 years stated that the overall average %EWL was 59.3 %. Additionally, the resolution rates of arterial hypertension, hyperlipidemia, obstructive sleep apnea, and type 2 diabetes were 72.4, 61.5, 87.0, and 70.9 %, respectively, according to seven studies that provided information about the long-term influence of LSG on obesity-related comorbidities [21], indicating that LSG seems to be associated with stable, long-term body weight loss. However, severe complications associated with LSG, such as staple line leaks, strictures, and bleeding should not be ignored. A review of 88 papers reported 191 leaks in 8920 patients (leak rate of 2.1 %) [22] that were difficult to manage, resulting in a high rate of revisional procedures in some studies.

For these reasons, LGCP was subsequently introduced. LGCP represents the evolution of less invasive LSG and

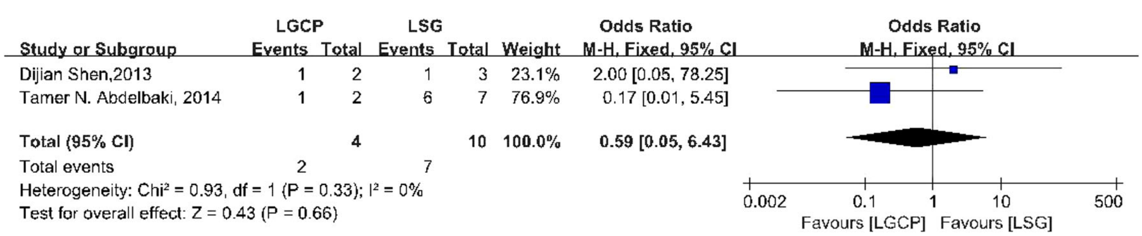


Fig. 5 Forest plot of comparison between LGCP and LSG in resolution of diabetes mellitus

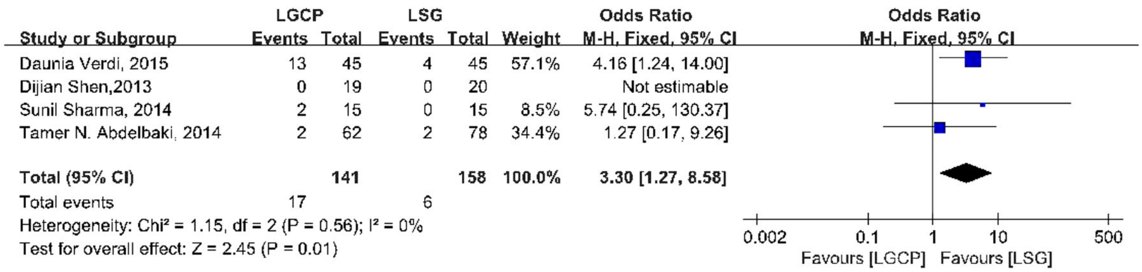


Fig. 6 Forest plot of comparison between LGCP and LSG in postoperative major morbidities

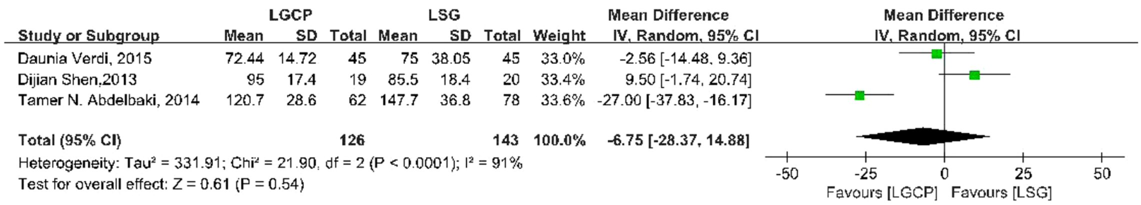


Fig. 7 Forest plot of comparison between LGCP and LSG in operative time

reduces the stomach volume without the need for cutting or stapling. The LGCP technique has not yet been validated, however, and controversies exist regarding its reliability. In terms of weight loss, some studies comparing short- or mid-term results of LGCP and LSG demonstrated a comparable %EWL between these two restrictive bariatric procedures [23–26]. However, several other studies indicated that LGCP is inferior to LSG as an approach to weight loss [27–29]. According to the pooled data of our meta-analysis, a significantly greater %EWL was achieved by LSG at the follow-up time points of 3 months (Z=2.26, p=0.02), 6 months (Z=4.49, p<0.00001), and 12 months (Z=6.99, p<0.00001). This difference in %EWL may be related to plasma ghrelin levels and gastric receptive relaxation [30]. Only one of the included studies with a patient follow-up duration of 3 years showed an EWL of 39.5 %±14.4 % for LGCP versus 50.0 %±20.3 % for LSG (p=0.1380) [16]. Therefore, large trials comparing obesity between LGCP and LSG with longer follow-up periods seem necessary. A 12-year experience of LGCP reported by Talebpour et al. [31] demonstrated that the mean postoperative EWL was 66 % after 3 years (251 cases), 62 % after 4 years (176 cases), 55 % (28–100 %) after 5 years (134 cases), and 42 % after 10 years (35 cases).

Besides weight loss, the resolution rate of comorbidities also plays an important role in evaluating efficacy. In this meta-analysis, both LGCP and LSG were effective ways to treat obese patients with type 2 diabetes mellitus. As the improvement of relevant chemical parameters of type 2 diabetes after LSG was well affirmed, the effect of LGCP has been mired in some controversy. In a study of 33 patients by Fried et al. [32], the plasma glucose levels dropped from 162.8 to 112.6 mg/dL and the glycosylated hemoglobin levels dropped from 6.4 % to 5.1 % by 6 months after LGCP. However, Taha et al. [33] reported a postoperative glycosylated hemoglobin level of 7.5 % at 12 months compared with a baseline of 7.9 % in 55 patients.

Comparison of safety between LGCP and LSG is necessary. Major complications have conventionally been defined as adverse events requiring reoperation or readmission for more than 7 days. However, some studies only listed the complications without precisely defining them; therefore, it was difficult for us to distinguish exactly between major and minor complications. Our meta-analysis of four studies proved that LGCP was associated with statistically more major complications than LSG. The details of these major complications are presented in Table 2. In addition, one systematic review reported that the rate of gastric leakage and perforation after LGCP was 1.6 % [34], which actually challenges the common notion that deficiency of a long staple line would reduce the occurrence of leaks and perforation.

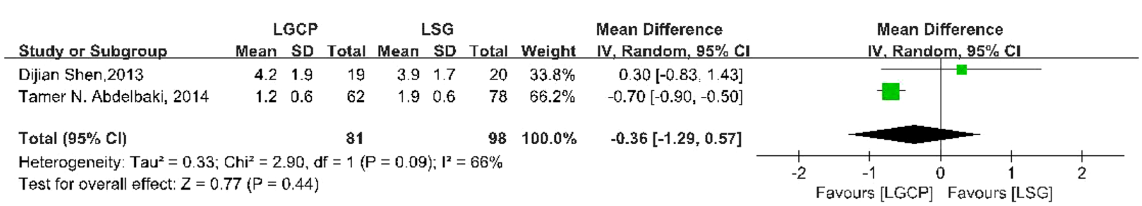


Fig. 8 Forest plot of comparison between LGCP and LSG in postoperative hospital stay

Table 2 Details of major complications

	LGCP			LSG		
References	*n*	Complications	Treatment	*n*	Complications	Treatment
Daunia Verdi, 2015, Italy [13]	1	Fistula and gastric prolapse	LSG	2	Anemia	Transfusion
	11	Gastric fundus prolapse	6 LSGs 5 Fundectomies	2	Gastric lumen stenosis	Endoscopic dilation
	1	Gastric antrum internal invagination	Adhesiolysis			
Total	13			4		
Tamer N. Abdelbaki, 2014, Egypt [15]	1	Gastric obstruction	Fundectomies	1	Gastric obstruction	Endoscopic dilation
	1 4	Gastric obstruction Nausea, vomiting	1 Reoperation	1 1	Bleeding Nausea, vomiting	1 Reoperation
				1	Port site hernia	
Total	6			6		
Sunil Sharma, 2014, India [16]	1	Leak	Reoperation			
	1	Gastric obstruction	Reoperation			
Total	2			0		

LGCP laparoscopic greater curvature plicationis, *LSG* laparoscopic sleeve gastrectomy

Our meta-analysis carries inherent limitations. Only four studies involving 141 patients who underwent LGCP and 158 patients who underwent LSG were included, the sample size of two studies was less than 20. Such small number of studies does not allow us to assess the publication bias by a funnel plot described by Egger [35], and the finite number of patients and events lead to a wide confidence interval. Although a pooling data based on our meta-analysis can compensate for this limitation to some extent, the statistical power of the comparative results remains limited. Furthermore, three studies were non-randomized controlled trials, which may cause selection and detection bias. However, Abrahama et al. [36] demonstrated that meta-analysis of high-quality non-randomized controlled studies of surgical procedures may be as accurate as RCTs. Actually, all these three non-randomized controlled trials were high-quality studies scoring eight points.

It should also be noted that we were unable to obtain detailed information from any of the four studies about the surgeons' experience with LGCP and LSG that might have impacted the surgical outcomes; this may have led to deviations in our comparisons, especially in postoperative major morbidities. In the study of Verdi et al.[13], 12 out of the 13 reported major morbidities are of the same "nature", thus gastric wall prolapse/invagination. We could not ascertain there was an intrinsic flaw in LGCP that was related to this kind of complication or these major morbidities were just caused by inexperience.

Moreover, the meta-analysis was not done for cost-effectiveness due to the limited data. Thus, in this meta-analysis, the advantage of LGCP on costs cannot be concluded, which may be important for its popularity in a developing country.

Conclusion

This systematic review suggests that LGCP is inferior to LSG not only in terms of providing effective weight loss, but also in terms of safety. However, considering the limitations cited above, conclusions should be drawn with prudence and care. A multicenter RCT should be performed to offer more concrete evidence regarding this subject.

Conflict of Interest The authors declare that they have no conflict of interest with the materials presented here.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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