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Reported appetite, taste and smell changes following Roux-en-Y gastric bypass and sleeve gastrectomy: Effect of gender, type 2 diabetes and relationship to post-operative weight loss

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ABSTRACT

Reduced energy intake drives weight loss following Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) procedures. Post-operative changes in subjective appetite, taste, and smell and food preferences are reported and suggested to contribute to reduced energy intake. We aimed to investigate the prevalence of these changes following RYGB and SG and to evaluate their relationship with weight loss.

98 patients post-RYGB and 155 post-SG from a single bariatric centre were recruited to a cross-sectional study. Participants completed a questionnaire, previously utilised in post-operative bariatric patients, to assess the prevalence of post-operative food aversions and subjective changes in appetite, taste and smell. Anthropometric data were collected and percentage weight loss (%WL) was calculated. The relationship between food aversions, changes in appetite, taste and smell and %WL was assessed. The influence of time post-surgery, gender and type 2 diabetes (T2D) were evaluated.

Following RYGB and SG the majority of patients reported food aversions (RYGB = 62%, SG = 59%), appetite changes (RYGB = 91%, SG = 91%) and taste changes (RYGB = 64%, SG = 59%). Smell changes were more common post-RYGB than post-SG (RYGB = 41%, SG = 28%, $p = 0.039$). No temporal effect was observed post-RYGB. In contrast, the prevalence of appetite changes decreased significantly with time following SG.

Post-operative appetite changes associated with and predicted higher %WL post-SG but not post-RYGB. Taste changes associated with and predicted higher %WL following RYGB but not post-SG. There was no gender effect post-RYGB. Post-SG taste changes were less common in males (female = 65%, males = 40%, $p = 0.008$). T2D status in females did not influence post-operative subjective changes. However, in males with T2D, taste changes were less common post-SG than post-RYGB together with lower %WL (RYGB = 27.5 ± 2.7, SG = 14.6 ± 2.1, $p = 0.003$). Further research is warranted to define the biology underlying these differences and to individualise treatments.

1. Introduction

Bariatric surgery is the most effective treatment for patients with severe obesity, leading to sustained weight reduction, improved obesity-associated co-morbidities and decreased

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mortality (Sjostrom, 2013). The most commonly performed bariatric procedures globally are the Roux-en-Y gastric bypass (RYGB) and the sleeve gastrectomy (SG), accounting for 45% and 37% respectively of operations undertaken in 2013 (Angrisani et al., 2015). Observational studies and a limited number of randomised controlled studies suggest that RYGB and SG produce comparable health improvements in the short-term (Schauer et al., 2014; Sczepaniak, Owens, Shukla, Perlegos, & Garner, 2015). Other procedures, such as the adjustable gastric banding (AGB) are now less commonly performed (Angrisani et al., 2015).

Eating behaviour is a key determinant of the pathogenesis of obesity and weight loss achieved following bariatric surgery (Manning, Pucci, & Batterham, 2015; Scott & Batterham, 2011). An energy intake that consistently exceeds energy expenditure leads to weight gain and eventually obesity (Berthoud, 2011). Obese individuals subjectively rate energy-dense foods as more pleasant compared to lean individuals (Rissanen et al., 2002). In addition, weight gain and obesity have been linked to a reduction in taste sensitivity and smell perception (Miras & le Roux, 2010; Patel, DelGaudio, & Wise, 2015; A. C. Shin, Townsend, Patterson, & Berthoud, 2011). Furthermore, neuroimaging studies have revealed that obese subjects exhibit altered neural responses within reward regions in response to food cues (Atalayer et al., 2014; Rissanen et al., 2002).

The gastrointestinal (GI) tract is established as a key regulator of energy and glucose homeostasis and it is now clear that changes in gut-derived signals as a consequence of altered GI anatomy following bariatric surgery play a key role in driving reduced energy intake and weight loss (Dirksen et al., 2013a; Manning et al., 2015; Scott & Batterham, 2011). Following RYGB and SG patients report reduced hunger in the fasted state, increased post-meal satiety, changes in subjective taste and altered food preferences (Manning et al., 2015; Scott & Batterham, 2011). For example, a recent prospective study of 30 patients undergoing SG reported a 68% decrease in energy intake 6 months post-surgery sustained at 24 months post-surgery. 75% of patients in this study reported reduced preference toward sweet and fatty foods (Coluzzi et al., 2016).

In order to assess changes in subjective taste following bariatric surgery Tichansky et al. developed a questionnaire comprised of 23 questions. They reported that subjective taste changes were more common post-RYGB than following AGB surgery (Tichansky, Boughter, & Madan, 2006). Subsequently, Graham and colleagues used Tichansky's questionnaire in a cross-sectional study to evaluate taste changes following RYGB in patients who were a median 19 months post-RYGB (Graham, Murty, & Bowrey, 2014). They added 10 additional questions assessing subjective changes in appetite, smell and food aversions. They found that 93% of patients reported a change in appetite, 73% a change in taste, 42% a change in smell and 73% developed food aversions. Additionally, they reported that patients who developed food aversions achieved higher absolute post-operative weight loss and greater reduction in body mass index (BMI) (Graham et al., 2014). Zerrweck et al. using the questionnaire from Graham et al., reported that appetite, taste, smell and food aversions were equally common following RYGB and SG at 10 months post-surgery (Zerrweck et al., 2015). However, it remains unclear whether these subjective changes in appetite, taste and smell are a consequence of weight loss *per se* or if they are mediated by bariatric procedure-dependent physiological changes. The subjective hedonic value of sweet foods has been shown to reduce following RYGB (Ochner et al., 2011, 2012; Scholtz et al., 2014). This effect was not observed in BMI-matched subjects following AGB, suggesting that post-RYGB hedonic responses to food change independent of weight loss (Scholtz et al., 2014).

The impact of bariatric surgery on objectively assessed olfaction and taste sensitivity is controversial, in part due to methodological issues. There are reports of improved post-operative taste sensitivity for sweet, salty, sour and bitter (Altun et al., 2016; Holinski, Menenakos, Haber, Olze, & Ordemann, 2015), no taste sensitivity changes (Pepino et al., 2014) and improved olfactory sensitivity (Holinski et al., 2015). There is also a suggestion of a difference between RYGB and SG with improved olfactory sensitivity post-SG but not post-RYGB (Jurowich et al., 2014).

Taste and smell perception are complex processes, integrating a range of sensory, cognitive and hormonal signals (Cummings, 2015; Miras & le Roux, 2010). Gender, obesity, presence of T2D and nutritional status (vitamin B12 and zinc levels) have all been reported to impact upon gustatory and olfactory function (Bustos-Saldana et al., 2009; Deglaire et al., 2015; Fabian, Beck, Fejerdy, Hermann, & Fabian, 2015; Hwang, Kang, Seo, Han, & Joo, 2016). The tendency to like fatty and salty tasting foods has been shown to have a linear relationship with increasing BMI in both males and females (A. C. Shin et al., 2011). However, a liking for sweet foods is more commonly reported by obese females compared to obese males (Deglaire et al., 2015) and females outperform males in their ability to detect certain odours (Doty & Cameron, 2009). T2D *per se* has been linked to impaired taste sensitivity, particularly for sweet stimuli and to impaired olfaction (Bustos-Saldana et al., 2009). Following RYGB, patients with T2D loose significantly less weight compared to patients who do not have T2D (Courcoulas et al., 2015). However, there are no reports comparing the prevalence of changes in subjective appetite, taste or smell following bariatric surgery in people with T2D compared to people without T2D.

Following RYGB and SG, circulating gut hormone levels are markedly altered and these changes are suggested to contribute to post-operative appetite changes (Yousseif et al., 2014). Patients with a poor response to surgery experience increased hunger and reduced satiety levels. In addition, an attenuated gut hormone response is seen in poor weight loss responders compared to good weight loss responders (Dirksen et al., 2013b; Manning et al., 2015). Interestingly, gut hormones are present in saliva and their cognate receptors are found on taste buds and olfactory neurons (Acosta et al., 2011; Cummings, 2015; Loch, Breer, & Strotmann, 2015; Shin et al., 2008). Hence, it is plausible that gut hormones mediate gustatory and olfactory changes following bariatric surgery through weight-independent mechanisms. Of note, RYGB and SG are anatomically very different and differentially impact upon circulating gut hormone levels (le Roux et al., 2007; Yousseif et al., 2014). These differences may in turn result in post-procedural differences in appetite, taste and smell. Whilst the development of food aversions following SG and RYGB has been linked to increased weight loss, it remains to be established whether subjective change in appetite taste or smell associate with weight loss (Graham et al., 2014).

We hypothesized that post-operative subjective changes in appetite, taste and smell would differ between SG and RYGB patients and be influenced by gender and the presence of T2D. In