Complex relationships requiring long-term follow-up: Obesity, bariatric surgery-induced diabetic remission, and the diabetic foot

Catherine Gooday, Rachel Murchison, Ketan Dhatariya

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Article points

1. Obesity is a risk factor for foot complications.
2. Unlike the macrovascular complications of diabetes such as atherosclerosis, there is limited evidence that neurological complications such as peripheral neuropathy improve.
3. Risk of foot complications in people whose diabetes has improved or gone into remission following significant weight loss remains at at-risk of foot complications and should remain under life-long follow-up for diabetic foot disease.

Key words

- Bariatric surgery
- Diabetic foot disease
- Diabetic remission
- Obesity

Authors

Catherine Gooday is Principal Podiatrist. Rachel Murchison is Podiatrist in Diabetes. Ketan Dhatariya is Consultant Endocrinologist. All are based at the Diabetic Foot Clinic, Elsie Bertram Diabetes Centre, Norwich.

Obesity is fuelling the rapid, worldwide rise in the incidence of type 2 diabetes. Surgery to aid weight loss and induce diabetes remission is becoming more common. Despite improvements in biochemical markers following bariatric surgery, and subsequent reductions in cardiovascular morbidity and mortality, diabetic neuropathy does not show the same improvement. Patients with established diabetic neuropathy remain at high risk of developing foot complications following bariatric surgery, and may be exacerbated by increased activity levels following dramatic weight loss. Here, the authors present a case highlighting the necessity of keeping this patient group – even if their diabetes enters remission – under the care of diabetic foot protection teams and, if necessary, specialist multidisciplinary foot clinics.

The incidence of obesity is a major public health problem. The World Health Organization (WHO; 2013) reports that obesity levels worldwide have doubled in the past 30 years. Data from Public Health England (2013) show that the prevalence of obesity among adults rose from 15% to 25% between 1993 and 2012, with more recent reports suggesting that the prevalence may rise to >50% by 2030 (State of the Nation's Waistline, 2014).

NICE (2006) defines adults with a BMI ≥25 kg/m^2 as overweight, and those with a BMI of ≥30 kg/m^2 as obese. Further NICE classifications of obesity by BMI in adults are as shown in *Table 1*.

Being overweight or obese can increase the risk of health problems including coronary heart disease, stroke, some cancers, and reduce life expectancy (Guh et al, 2009). Obesity is also recognised as one of the leading causes of type 2 diabetes (Mokdad et al, 2000). The WHO (2013) reports that 44% of cases of diabetes are attributable to overweight and obesity, while other authors suggest this figure could be as a high as 80%–85% (Diabetes UK, 2012).

Table 1. NICE (2006) classifications within obesity by BMI in adults.

Obesity class	BMI (kg/m^2)
I	30–34.9
II	35–39.9
III	≥40

The impact on the foot

One of the complications of diabetes is foot ulceration, which can affect up to 25% of people with diabetes during their lifetime (Bakker, 2011). Neuropathy, peripheral arterial disease (PAD) and foot deformity (resulting in altered biomechanics) have all been associated with the development of foot ulceration in diabetes (Abbott et al, 2002). Foot ulceration has been identified as the precursor of amputation in 84% of cases (Pecoraro, 1990), and the risk of amputation is 20-times higher among people with diabetes than those without (Kerr, 2012).

Alongside the risk described earlier there are several factors that combine to further increase the risk of obese people with diabetes developing foot problems. Foot function and shape can change in the presence of obesity, altering gait patterns (Stuck et al, 2008). Although obese people are often inactive, pressures going through their feet when weight bearing will be higher than in non-obese people, and contribute to an increased risk

of ulceration. Sohn et al (2011) demonstrated a BMI ≥40 kg/m^2 to be a significant risk factor for ulceration. Furthermore, the ability to effectively self-care is often reduced in obese people due to their inability to reach or see their feet. Purchasing appropriately fitting (i.e. wide) footwear can also be difficult.

Butterworth (2012) reports a significant association between increased BMI and foot pain. It has previously been reported by Stuck et al (2008) that there is increased plantar pressure as a result of biomechanical changes and increased load going through the foot which could contribute to the foot pain. However, in the presence of diabetic neuropathy, pain signals will be reduced or absent and people will continue to mobilise on a foot subjected to potentially damaging trauma. This may account in part for the increased risk of foot ulceration in obesity that is often associated with diabetes.

Management of obesity and diabetes

The management of obesity and diabetes and their related complications represents a considerable financial burden. Overweight or obesity costs the NHS more than £5 billion annually (Scarborough, 2011). An economic analysis by Kerr (2012) found that the annual cost of diabetic foot disease to healthcare agencies in the UK exceeds £732 million – equating to £1 in every £150 of the NHS budget. With the increasing prevalence of these conditions, these costs are likely to escalate.

Improved diabetes control reduces the risk of developing microvascular complications of diabetes (UK Prospective Diabetes Study Group, 1998). A reduction in weight has been shown to improve glycaemic control, and weight loss is now advocated as one of the mainstays of treatment in type 2 diabetes (Inzucchi, 2012). This can be achieved through lifestyle changes, pharmacological or surgical management, or a combination of these approaches.

Bariatric surgery achieves weight loss by restrictive or malabsorption mechanisms. It has been shown that diabetes goes into remission – by increasing the efficiency of insulin secretion and decreasing insulin resistance – and that this can be maintained (Sjostrom et al, 1999). These improvements may lead to a reduction in some diabetes-related complications, hyperlipidaemia, hypertension and, ultimately, mortality rates (Pories et al, 1992). Bariatric surgery is recommended by NICE (2006) as a treatment for obesity for those adults in whom the criteria listed in *Table 2* are met.

Case study

This case describes a woman with type 2 diabetes diagnosed in 1989. She was originally referred to the diabetic foot clinic in 2007 for treatment of an ulcerated right first metatarsophalangeal joint (MPJ). At this time, her HbA_{1c} was 69 mmol/mol (8.5%). She was obese (class III), with a BMI of 54.5 kg/m^2. She required assistance to put on her shoes and with general foot care. There was evidence of obesity-related foot deformity with a flat foot shape evident on X-ray (*Figure 1*). She had palpable foot pulses, but was neuropathic with negative monofilament perception and vibration perception in excess of 49 volts.

The ulceration was initially slow to heal. The patient agreed to treatment in a non-removable below knee cast and the ulceration improved dramatically (*Figure 2*) and healed within 3 months. Hospital footwear (*Figure 3*) and custom-made orthotics were provided and their efficacy was checked with an F-Scan® (Tekscan) in-shoe pressure measurement system. Following resolution of the problem the patient was discharged into the care of the local foot protection team (FPT) for ongoing management.

She was referred back to the foot clinic by the FPT after 5 years, with a recurrence of the right first MPJ ulcer. On assessment she had a hot swollen foot and ankle with a temperature difference of 3.5°C compared with the contralateral foot. She had undergone bariatric surgery 1 year previously and her weight had dropped by 46 kg and her BMI had fallen to 34.6 kg/m^2. Her diabetes control had improved significantly, with her HbA_{1c} being 40 mmol/mol (5.8%). Although her diabetes had not gone into remission in the long term, she had initially stopped all treatment post-surgery for her diabetes and was then restarted on gliclazide (80 mg twice daily) as her HbA_{1c} had started to rise again and at 18 months post-surgery was 58 mmol/mol (7.5%). Although diabetes has been found to go into remission following bariatric surgery, complete and long term resolution rates vary considerably in

Table 2. Bariatric surgery is recommended by NICE (2006) as a treatment option for adults with obesity if all of the following criteria are fulfilled.

- They have a BMI of 40 kg/m^2 or more, or between 35 kg/m^2 and 40 kg/m^2 and other significant disease (for example, type 2 diabetes or high blood pressure) that could be improved if they lost weight.
- All appropriate non-surgical measures have been tried but have failed to achieve or maintain adequate, clinically beneficial weight loss for at least 6 months.
- The person has been receiving or will receive intensive management in a specialist obesity service.
- The person is generally fit for anaesthesia and surgery.
- The person commits to the need for long-term follow-up.

Page points

1. In the present case, the patient reported that she had become more physically active and had decided to stop going for podiatry treatment because she was enjoying her new found freedom.
2. Her weight loss had also affected the size of her foot and she had not contacted the orthotic service to have her footwear reassessed; this may have contributed to the development of the ulceration.
3. The possibility of an underlying acute Charcot's neuroarthropathy was suspected alongside the ulceration.

Figure 1. X-ray demonstrating the flat foot deformity of the case reported.

the literature from 16%–60% (Keogh, 2012). These differences are in part due to variations in definition of remission and length of follow-up. They also often reflect the baseline characteristics of the selected patient group including duration of diabetes and HbA_{1c} prior to surgery.

Figure 2. Plantar ulcer of the case reported.

As a result of her weight loss, she reported that she had become more physically active and had decided to stop going for podiatry treatment because she was enjoying her new-found freedom of being able to look after her own feet and "did not want to be a burden". Her weight loss had also affected the size of her foot and she had not contacted the orthotic service to have her footwear reassessed; this may have contributed to the development of the ulceration.

The possibility of an underlying acute Charcot's neuroarthropathy was suspected alongside the ulceration and the patient was treated with dressings, debridement, and a non-removable below-knee total-contact cast. An X-ray showed no bone abnormalities and an MRI demonstrated diffuse subcutaneous oedema of the foot, but was not diagnostic. Despite these findings, the clinical indications remained highly indicative of an early Charcot's neuroarthropathy, with a temperature difference of >2°C–4°C in the ulcerated foot when compared to the contralateral foot, and was treated accordingly.

The ulceration healed after 2 months in the cast. The patient remained in the cast for a further 3 months. After 5 months the bilateral temperature difference settled and remained consistently <2°C.

She was initially transferred into a below-knee walker, then hospital footwear and was discharged 7 months after her initial referral. During the time the patient was in the cast for the treatment of Charcot's neuroarthropathy, the ulceration healed quickly. The application of the cast facilitated ulcer healing and the early suspicion of Charcot's

Figure 3. Custom made footwear for the case reported.

neuroarthropathy and quick treatment resulted in no further foot deformity.

The patient was discharged back to the care of the FPT and given advice on the continued importance of foot care and foot checks.

Discussion

In the case described – despite significant improvements in diabetes control and subsequent improvement in mortality risk – neuropathy and previous foot deformity described by Pinzur (2005) remained following bariatric surgery and contributed to the development of further ulceration and Charcot's neuroarthropathy.

Obesity often restricts physical activity and following successful weight loss surgery as in the case described people are likely to become more active. Sohn (2011) demonstrated a J-shaped association between BMI and diabetic foot ulcers, with people of healthy weight being at elevated risk compared those with a BMI 25 kg/m^2–34.9 kg/m^2. The authors cannot account for this but suggest it might be another instance of the "obesity paradox", where people who are moderately overweight are at lower risk than those of a healthy weight – perhaps in this instance due to being less active. The significant weight loss achieved following bariatric surgery moved this patient from one end of the spectrum to another. When a person is significantly overweight, though they are relatively inactive, the pressures going through the foot can be high albeit for a short period of time, however when weight drops and activity levels increase the pressure can be lower but more frequent.

The relative inactivity of people with obesity can lead to osteopenia. People who have undergone bariatric surgery have increased bone turnover and decreased bone mass (Coates et al, 2004; Stein et al, 2013). Neuropathy and increased physical activity following bariatric surgery combined with a previous decrease in bone density may increase the risk of either major or repeated microtrauma to the foot. Trauma is one of the identified risk factors for the development of acute Charcot's neuroarthropathy. This change in bone density may have been one of the precipitating factors in the case described, although further work needs to be done to confirm this hypothesis.

In practice: Providing care for this complex population

The authors have experienced many similar cases where patients' BMI has dropped significantly following bariatric surgery and they have subsequently become more active (Murchison, 2014). All of these patients had pre-existing neuropathy and then developed ulceration and/or Charcot's neuroarthropathy, and been treated with non-removable casts. For people who have regained their independence the application of a cast for several months is extremely frustrating and may lead to weight gain through disillusionment and inactivity. The need for prolonged casting is likely to have a significant impact on quality of life, often rendering these patients unable to carry out simple daily activities; these patients need to be carefully monitored and, if possible, strategies introduced to help them manage.

Not every patient who undergoes bariatric surgery goes on to develop foot problems; for many this surgery is without further complications, however clinicians need to ensure that both patients and clinicians are aware of and monitored for potential foot problems.

Programmes for weight loss must take into account the potential increased risk of the patient developing foot ulceration. Careful consideration must be given to footwear and regular monitoring of the foot undertaken. Zimmet et al (2011) recommend that bariatric surgery could be considered earlier in the treatment of type 2 diabetes and, therefore, reduce the development of complications. If successful, management of obesity and improvements in diabetes control are achieved early in disease duration then the complication of neuropathy may not develop. The improvement in mortality and morbidity associated with macrovascular disease might be transferable to microvascular complications.

Recommendations

The authors make the following recommendations for the foot care of people who have undergone bariatic surgery but in whom existing microvascular and peripheral neurological damage leaves them at continued risk of podiatric complications:

- People who have undergone significant weight loss after which their diabetes has either improved

Page points

1. In the case described – despite significant improvements in diabetes control and subsequent improvement in mortality risk – neuropathy and previous foot deformity remained following bariatric surgery and contributed to the development of further ulceration and Charcot's neuroarthropathy.
2. Neuropathy and increased physical activity following bariatric surgery combined with a previous decrease in bone density may increase the risk of either major or repeated microtrauma to the foot.
3. Programmes for weight loss must take into account the potential increased risk of the patient developing foot ulceration.

"This case illustrates the importance of continued surveillance not only of biochemical markers, but also for microvascular and peripheral neurological complications – specifically of the foot [in the post-bariatric surgical patient]."

significantly or gone into remission need to continue to receive podiatric care from the FPT and, if necessary, multidisciplinary foot teams. The level of care needed should continue to be assessed according to their risk status as defined by the NICE guideline CG10 (2004). The recognised triad of complications – neuropathy, ischemia, and foot deformity – and the risk of foot ulceration, remain. Continued foot care education for this group of people is critical to try and prevent the development of acute foot complications such as ulceration and Charcot's neuroarthropathy.

- Establishing links between FPTs and bariatric services may be one way to ensure that these people do not fall through the system and present late. Identifying patients' foot risk status prior to surgery as part of peri-operative assessment could be one method of ensuring that clinicians remain vigilant as to the risk of future foot problems, thereby ensuring they remain on the appropriate foot care pathway.
- Patients with pre-existing foot complications such as neuropathy and peripheral arterial disease undergoing bariatric surgery need to be properly counselled as to their continued risk of foot problems post-surgery.
- Foot screening surveillance programs need to include this group of people in which diabetes has gone into remission and they need to be identifiable on GP registries. They need continued monitoring to check that diabetes does not reoccur. A new READ code for "diabetes in remission" needs to be created to allow this to happen.
- Commissioning teams developing referral pathways must take into account this unique group of people.

Conclusion

Long-term follow-up is crucial following bariatric surgery and is stressed by NICE (2006). This case illustrates the importance of continued surveillance, not only of biochemical markers, but also microvascular and peripheral neurological complications – specifically of the foot. Diagnosis may be delayed – and outcomes poor – if healthcare professionals fail to register the underlying neuropathy in those individuals without a current diagnosis of diabetes, or if the patient no longer has FPT access. ■

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