RESEARCH ARTICLE

Detection of the genial spinal canal in atrophic mandibles with a CBCT: a cadaver study

¹F Birkenfeld, ²M Becker, ²M Sasse, ¹V Gassling, ³R Lucius, ¹J Wiltfang and ²M Kern

¹Department of Oral-Maxillofacial-Surgery, University Hospital Schleswig-Holstein, Kiel, Germany; ²Department of Prosthodontics and Dental Materials, University Hospital Schleswig-Holstein, Kiel, Germany; ³Institute of Anatomy, Christian-Albrechts University Kiel, Kiel, Germany

Objectives: The use of a single midline implant to retain a complete mandibular denture when more implants cannot be used is an incipient treatment modality. However, in the mandibular symphysis, the genial spinal canal (GSC) is an anatomical structure with neurovascular content that can be harmed during dental implant surgery. The purpose of the present study was to use CBCT of edentulous atrophic cadaver mandibles and evaluate how often the simulated placement of a single midline implant would contact the GSC if present. **Methods:** CBCT scans of 47 edentulous cadaver mandibles were performed. A digital simulation of the placement of a single midline implant (3.8 × 11.0 mm) was performed, and the implant–GSC contact was evaluated.

Results: A GSC was detected in the CBCT scan of all atrophic mandibles. In 42 cases (89.4%), the single midline implant contacted the GSC. On average, the five cases without GSC contact had a higher alveolar ridge (4.1 mm) and a lower GSC (0.79 mm) than did the cases with GSC contact.

Conclusions: CBCT scans can adequately detect the GSC during pre-surgical diagnostics. There is a high risk of implant–GSC contact during surgery of the anterior mandible. However, the clinical relevance of such a contact is not known yet, because none of the clinical studies evaluating a single midline implant has reported any implant–GSC contact-related complications.

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Introduction

The use of a single midline implant to retain a complete mandibular denture when more implants cannot be used is an incipient treatment modality,^{1–3} and this technique has been investigated since 1993.⁴ This procedure is discussed controversially by experts owing to the limited mechanical stability of the prostheses and the unknown long-term survival of the single implant.¹ Medium-term survival rates have been reported to be between 62.5% and 100%.¹

For many patients, the recommended two implants in the mandible for prosthetic rehabilitation are not affordable.⁵ Edentulous mandibles are often reported in individuals with a low income.⁶ Therefore, to increase the comfort, retention and stability of complete single dentures for individuals who cannot afford more implants, the use of a single midline implant might be justified, and the benefits of a single midline implant have been shown for an observation time up to 6 years.^{3,7}

However, the anatomical aspects of the genial spinal canal (GSC) should be considered (Figure 1).⁸ The GSC is an anatomical structure in the inner curve of the

Correspondence to: Dr Falk Birkenfeld. E-mail: f.birkenfeld@mkg.uni-kiel.de

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Figure 1 Atrophic mandible. (a) Frontal overview. The double arrow indicates the position of the height of the mandible; the arrowheads indicate the mental foramina. (b) Oral view of the mandible. The bracket indicates the position of the width. The arrow indicates the genial spinal canal foramen. The arrowheads indicate the alveolar foramen. Inset, the arrow indicates the genial spinal canal foramen; the double arrow indicates the edge of the foramen.

mandible at the symphysis. The GSC contains a small blood vessel of the lingual artery and the mylohyoid nerve or a part of the lingual nerve.^{8–11} Destruction of the GSC during implant placement might result in clinical complications, such as bleeding or paraesthesia. However, the interforaminal mandibular region has been described in the literature as safe for implant placement.^{10,12,13}

Pre-surgical diagnostics with a panoramic X-ray is the gold standard prior to implant placement.¹⁴ In recent years, the introduction of CBCT has allowed a three-dimensional examination of the inferior alveolar nerve canal in multiplanar reconstructions or in a sagittal view of the mandible prior to implant placement.^{15,16} However, to the best of our knowledge, CBCT has not been applied in any clinical studies using the single midline mandibular implant (prior or after implant placement). Therefore, it is not known how often implant placement in the mandibular midline might interfere with the GSC.

Therefore, the purpose of the present study was to use CBCT of edentulous atrophic cadaver mandibles to evaluate how often the simulated placement of a single

midline implant would contact the GSC if present. Additionally, macroscopic examinations of the atrophic mandibles were performed to identify the location of the GSC.

Methods and materials

47 edentulous atrophic cadaver mandibles of the Institute of Anatomy at the Christian-Albrechts University at Kiel, Germany, were used for this investigation. The sex and age of 23 (of 47) cadavers could be determined (females, 15; males, 8; mean age, 78.6 years). The mandibles were scanned for CBCT (KaVo 3D eXam™; KaVo Dental GmbH, Biberach, Germany). The scans were performed with voxels of $0.250 \times 0.250 \times 0.250$ mm and were evaluated with the KaVo eXam Vision software (KaVo Dental GmbH) in the implant view screen. The sagittal view was set to the midline of the mandible, and a picture was created. Next, pictures were captured, and the implant (dimensions of 3.8×11.0 mm) placement was simulated (CorelDraw® Graphics Suite X6; Corel Corporation, Ottawa, ON). Two different implant positions were simulated. The first simulation was performed with a cervical bone plateau of 5.0 mm, and the second simulation was performed with a plateau of 4.0 mm (Figure 2). The cervical plateau was chosen to optimize the bone for the implant. The 4.0-mm plateau should demonstrate an implant position with a minimum of cervical bone around the implant shoulder. The 5.0-mm plateau should demonstrate the optimal bone placement before implant insertion. There were three steps to find the simulated implant position: (1) position the cervical plateau to minimize the vertical bone loss caused by surgery; (2) position the simulated implant position under the cervical plateau; and (3) angle the implant up to 40° (maximum of 40° , balancing the angle by abutment).

In addition, the mandibular dimensions were recorded. The vertical height and sagittal width of the symphysis and the distance of the mandibular edge to the GSC were measured (Figure 1).

Ethical approval

All cadavers were available at the Institute of Anatomy at the first author's institution and were used according to the institutional and national ethical and legislative frameworks. Human skulls were from bequeathed body donors of the Institute of Anatomy of the Christian-Albrechts University at Kiel.

Statistical analysis

The data were analysed using WinSTAT for Windows Excel® (R. Fitch Software, Bad Krotzingen, Germany). The data fit the normal distribution (Kolmogorov–Smirnov test; $p > 0.05$). Therefore, the data are reported as means $\pm$ standard deviations.

Figure 2 Simulation of a single midline implant. The red arrows indicate the genial spinal canal. (a) Sagittal picture of the mandible to evaluate the genial spinal canal. (b) Sagittal picture of the mandible to simulate the implant placement; the red line indicates a cervical bone width of 5.0 mm. (c) Sagittal picture of the mandible to simulate the implant placement; the turquoise line indicates a cervical bone width of 4.0 mm. (d) Panoramic overview of the atrophic mandible; the vertical blue lines indicate the position of the sagittal pictures a–c. Bar = 4.0 mm.

Results

A GSC was detected in all scanned mandibles ($n = 47$). In 42 cases (89.4%), the simulated implant placement, with a cervical plateau of 5.0 mm and a plateau of 4.0 mm, of a single midline implant (3.8×11.0 mm) demonstrated implant–GSC contact. There was no difference between the different plateaus. In five cases (10.6%), the simulated implant was at least 1.0 mm above the GSC.

The dimensions of the scanned mandibles are presented in Table 1. The width and height of the mandibular symphysis and the distance of the lower mandibular edge to the foramen of the GSC (edge to GSC) were recorded. In the five cases without implant–GSC contacts, the vertical anterior mandibular ridge height was approximately 24.0 mm, and the GSC was lower than the group with implant–GSC contacts. 13 cases demonstrated a second GSC, and 1 mandible showed a third GSC.

Discussion

To the best of our knowledge, this is the first report of a pre-surgical evaluation (in a cadaver study) of the

Table 1 Summarised dimensions of the scanned mandibles

Groups	Width (mm)	Height (mm)	Edge to GSC (mm)
$n = 42$	13.85 ± 1.61	19.92 ± 3.10	12.09 ± 3.69
$n = 5$	15.66 ± 2.27	24.08 ± 4.44	11.30 ± 2.86
$n = 47$	14.04 ± 1.75	20.36 ± 3.46	12.01 ± 3.59

GSC, genial spinal canal.

$n = 42$, subgroup of mandibles with contact with the GSC; $n = 5$, subgroup of the mandibles without contact with the GSC; and $n = 47$, all scanned mandibles. Edge to GSC (Figure 2).

GSC with CBCT scans for single midline implants in the atrophic mandible.

A GSC was detected with high resolution (voxel size of 0.250 mm) in all scanned atrophic mandibles. The simulation of a single midline implant (dimensions 3.8×11.0 mm) demonstrated an implant–GSC contact in 89.4% of cadavers. In this group, the alveolar ridge height was approximately 19.0 mm, and the GSC was approximately 12.0 mm above the mandibular edge. Similar findings were reported by Gahleitner *et al.*¹⁷ In the five cases where no implant–GSC contact was observed, the alveolar ridge was approximately 24.0 mm, and the GSC was closer to the mandibular edge (approximately 11.0 mm). In total, this is approximately 5.0 mm more bone in the vertical direction.

The anterior mandible is described as a rather safe region for surgical procedures,¹² and two interforaminal implants are recommended for complete mandibular dentures as a standard of care.⁵ With this surgical approach, an implant–GSC contact is not expected. However, single midline implants pose the risk of implant–GSC contact during surgery. Furthermore, the risk accompanied by implant–GSC contact cannot be assessed because no reports are available regarding implant–GSC contacts in various clinical trials.¹ In a recent multicentre study, no complications owing to haemorrhage or paraesthesia occurred during the placement of 163 single midline implants, even though the chance of implant–GSC contact is approximately 90.0% according to our results.³

Life-threatening haemorrhage has been described following implant placement in different regions of the mandible¹⁰ but not while placing implants in the mandibular midline. Therefore, these incidents cannot be related to GSC damage. However, microscopic and macroscopic evaluations of the GSC identified neurovascular content with anatomical variations.^{8,9} Our data supported these findings with a CBCT scan. Romanos *et al.*¹⁸ detected GSCs in 86.0% of scanned mandibles. The difference between our results and theirs can be explained by the resolution. Therefore, if pre-surgical diagnostics with cross-sectional imaging is to be meaningful, the highest resolution should be used.¹⁹ Romanos *et al.*¹⁸ also used CBCT but with a resolution of 1.0 mm, and we used a resolution of 0.25 mm.

Lustig *et al.*²⁰ even recommended an ultrasound before surgery. However, many midline implants have been placed in various clinical trials without reporting any post-operative complications related to the damage of the GSC.^{1–3} This result might occur because a ruptured blood vessel in the bony canal will limit the bleeding by coagulation. Post-operative observation and anticoagulation therapy should be considered for these patients to reduce life-threatening complications after implant placement.

Conclusion

There is a high risk of implant–GSC contact during surgery in the anterior mandible. However, the clinical

relevance of such a contact is not known yet, because none of the clinical studies evaluating the single midline

implant has reported any implant–GSC contact-related complications.

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