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·临床研究·

内镜及计算机导航辅助下颌面部异物取出5例临床分析

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【摘要】　目的　探讨内镜及计算机导航技术在颌面部异物取出手术中的应用方法及临床疗效，为该技术的临床应用提供参考。**方法**　本研究已通过医院医学伦理委员会批准，回顾性分析2018年1月至2024年12月在中山大学孙逸仙纪念医院收治的5例颌面部异物患者资料。所有患者均在术前接受CT扫描。术中根据异物位置、大小及与重要神经血管的毗邻关系，联合或单独采用内镜与计算机导航技术。通过内镜放大术野及直视下精准定位异物，或在计算机导航实时引导下，设计并验证最优手术路径，精准取出异物。记录并分析异物的种类、位置、长径、手术时长、切口长度、异物取出成功率、术后并发症及随访情况。**结果**　5例患者异物均被成功取出，成功率为100%。术中计算机导航系统定位准确，配准稳定性未受下颌骨运动明显影响；内镜提供了良好的术野照明与暴露。所有手术切口微小，术后均未发生异物残留、重要神经血管损伤、感染等严重并发症。术后1个月随访，患者恢复良好。**结论**　联合或单独采用内镜与计算机导航辅助技术，能为颌面部异物取出术提供清晰术野与实时定位，有效避开重要解剖结构，从而实现创伤最小化的安全、完整异物取出。该辅助技术显著提高了手术的精准性与安全性，具有临床推广价值。

【关键词】　颌面部；　异物；　内窥镜；　计算机辅助外科手术；　手术实时导航；　微创手术；　异物取出术
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Clinical analysis of five cases of endoscopic and computer navigation-assisted maxillofacial foreign body removal

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【Abstract】　Objective　To explore the application method and clinical efficacy of endoscopic and computerized navigation technology in maxillofacial foreign body removal surgery, and to provide a reference for the clinical application of this technology. **Methods**　This study, which was approved by the Medical Ethics Committee of the hospital, retrospectively analyzed the data of five patients with maxillofacial foreign bodies who were admitted to Sun Yat-sen Memorial Hospital, Sun Yat-sen University from January 2018 to December 2024. All patients underwent preoperative CT scanning. Intraoperatively, endoscopic and computer navigation techniques were used in combination or separately according to the location, size, and adjacency of the foreign body to important neurovascular vessels. The foreign body was precisely localized by endoscopic magnification and direct visualization, and the optimal surgical path was designed and verified under the real-time guidance of computerized navigation to accurately remove the foreign body. The type of foreign body, location, length and diameter, duration of surgery, length of incision, success rate of foreign body removal, postoperative complications, and follow-up were recorded and analyzed. **Results**　The foreign body was successfully re-

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moved in all five patients with a success rate of 100%. The intraoperative computerized navigation system was accurate in positioning, and the alignment stability was not significantly affected by mandibular movement; the endoscope provided good illumination and exposure of the operative field. All surgical incisions were small, and no serious complications, such as foreign body residue, important neurovascular injury, or infection, occurred after surgery. One month after the operation, the patients were followed up and recovered well. **Conclusion**　The combination of endoscopy and computer navigation or separately assisted technology can provide a clear field and real-time positioning for maxillofacial foreign body removal, effectively avoiding important anatomical structures, thus realizing safe and complete foreign body removal with minimized trauma. This assistive technology significantly improves the accuracy and safety of the operation and has clinical promotion value.

【Key words】 maxillofacial region; foreign body; endoscopy; computer-assisted surgery; real-time surgical navigation; minimally invasive surgery; foreign body removal

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颌面部异物虽临床少见，但常因外伤或医源性原因导致。异物性质以金属、玻璃、木头等多见。颌面部骨组织结构复杂且精细，厚薄不均；软组织间隙疏松且相互连通；加之咀嚼肌群带动颌骨频繁运动，导致异物移位，可能引发深部血管神经二次损伤、感染、慢性疼痛及功能障碍等并发症[1-2]。传统异物取出术存在固有局限：第一，其成功高度依赖术者基于术前CT等影像的立体空间想象力及对复杂解剖的熟悉程度；第二，为获得充分术野，常需较大切口，可能过度破坏正常组织，影响患者术后的感觉、功能与美观；第三，对于深部异物，术中因体位变动或探查操作易致其移位，使术前影像与术中实际情况难以对应。近年来，内镜及计算机导航技术在口腔颌面外科中逐渐得到广泛应用。内镜可深入术区，提供放大、明亮的直视术野，实现小切口下的可视化操作。计算机导航技术可通过术前三维重建患者病灶与周围重要解剖结构的相对位置关系，术中通过实时追踪手术器械位置，以实现外科手术微创化与精准化。二者为颌面部异物取出提供了全新解决方案。本文通过探讨内镜及计算机导航技术在颌面部异物取出手术中的应用方法及临床疗效，为该技术的临床应用提供参考。

1　资料和方法

1.1　研究对象

本回顾性研究获得中山大学孙逸仙纪念医院医学伦理委员会的批准（审批号：SYSJS-2023-143-01），所有患者均签署知情同意书。研究选取了2018年1月至2024年12月于中山大学孙逸仙纪念医院口腔颌面外科就诊的5例颌面部异物患者。纳入标准：①因颌面部外伤或医源性导致的异物残留；②术前均行口腔全景片、螺旋CT或CBCT检查以初步定位异物；③均在内镜和/或计算机导航辅助下成功完成异物取出术。

1.2　手术方法

1.2.1　内镜辅助　①通过全景片、CT和口内触诊确定异物大致位置，于近异物处设计黏膜切口；②内窥镜［（No. 22201020）Karl Storz Endoskope system，Tuttlingen，德国］光纤探头进入术区，同时根据异物位置调整角度进行寻找；③在内窥镜下定位异物后，将异物与周围结构分离，予以去除。

1.2.2　计算机导航辅助　①术前准备：将患者颌面部CT数据导入Mimics21.0软件，分割并三维重建下颌骨、异物及邻近重要结构（如血管、神经）；将重建模型导入手术计算机导航设备内（AccuNavi-A，UEG，中国），并根据异物位置设计颌面部配准点。

②术中操作：于颌骨牙槽部置入钛钉固定计算机导航参考架，或绑带式固定计算机导航参考架于颅骨；调试计算机导航系统，确保参考架及移动架摆位，使参考架和手术工具都落在红外线追踪定位装置的最佳视野内；完成参考架、计算机导航探针与3D重建后的颌骨模型的配准，使软件中的三维重建模型与术中患者实体能够一一对应；最后探针准确定位异物，沿探针方向开辟手术入路并将其安全取出。

1.2.3　内镜联合计算机导航辅助　①术前准备：

同1.2.2节。②术中操作：参考架固定方式同前；完成系统配准；通过器械转换适配器将计算机导航探针信号转导至内镜上，以内镜代替计算机导航探针进行异物定位，屏幕上实时显示计算机导航探针位置及内镜下病灶区域实况的双重视野；最后于内镜及计算机导航系统辅助下准确分辨异物，直视下将其安全取出。

2　结　果

本研究共纳入5例颌面部异物患者，其人口学特征、异物详情及治疗方案见表1。该队列包括4例男性及1例女性，平均年龄37.8岁（范围：19~72岁）。所有异物均经术前CT明确识别与定位。术中在CT影像引导下，结合内镜和/或计算机导航辅助，所有异物均被成功取出。患者对麻醉耐受良好，术中无疼痛。手术平均时长约73.8 min。术后平均住院时长1.6 d。术后随访1个月期间，所有患者均未发生感染、明显肿胀、感觉麻木或运动功能障碍。

表1　5例颌面部异物患者的临床特征及围手术期记录

Table 1　Clinical features and perioperative records of five patients of maxillofacial foreign bodies

Patients	Age/years	Gender	Maxillofacial foreign body conditions			Intraoperative and postoperative conditions			
			Location	Character	Long diameter/cm	Auxiliary methods	Duration of surgery/min	Complications	Post-operative hospitalization/days
1	72	Men	Right floor of the maxillary sinus	Implant	0.5	Endoscopy	85	No	3
2	19	Men	Right flank mandibular gap	Orthodontic anchorage screws	1.3	Endoscopy	70	No	1
3	47	Men	Right parapharyngeal space	Needle for local anesthetic	2.5	Computer navagation	45	No	1
4	25	Men	Subcutaneous tissue of the chin and right zygomatic region	Glass shards	0.8/0.5/0.1	Computer navagation	45	No	1
5	26	Women	Left base of the skull	Orthodontic anchorage screws	1.1	Endoscopy +computer navagation	124	No	2

2.1　病例1

2.1.1　一般资料　患者，男，25岁，因“玻璃仪器爆裂致颌面部多处异物残留1 d”就诊。外院及本院急诊已行清创并取出部分玻璃碎片。

2.1.2　查体　颌面部可见多处细小创口，缝线存留，伴活动性渗血及颜面部肿胀。余未见明显异常。

2.1.3　影像学检查　本院颌面部CT提示：左侧下颌皮下、左侧颏隆凸前方及右侧颧面部皮肤皮下软组织内多处异物残留（图1a~1c）。

2.1.4　诊断　颌面部外伤（颌面部多处异物）。

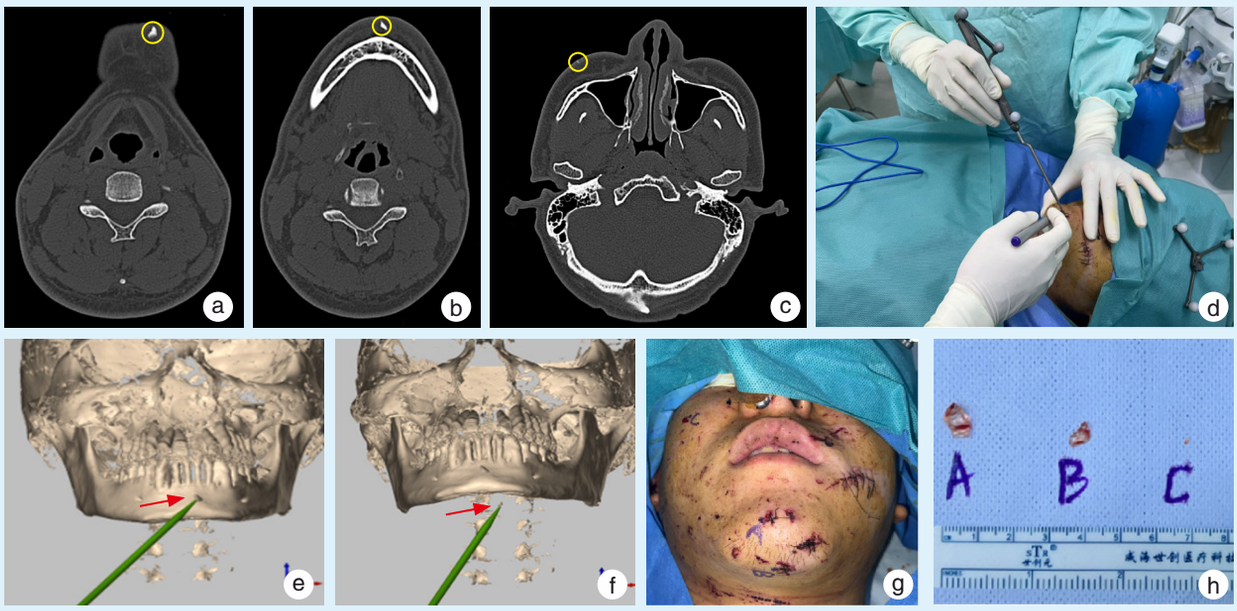
2.1.5　治疗计划　行计算机导航辅助下颏部、右颧面部异物取出术。

2.1.6　治疗过程与结果　①术前规划：将患者颌面部CT数据导入Mimics设计软件，并行上、下颌骨重建及异物标注；选取6个下颌牙作为解剖配准点。②术中操作：患者全身麻醉后，取平卧位，常规消毒铺巾；因异物分布于上下颌区域，采用头带将计算机导航参考架固定于颅骨；完成系统校准与点配准后，在计算机导航实时引导下，精确定位左侧下颌、左侧颏部及右侧颧面部3处皮下异物并记录入路方向；拆除原创口缝线，沿规划路径完整取出3枚玻璃异物；术区彻底止血后分层缝合（图1d~1h）。③术中及术后情况：手术历时约45 min，术中出血2 mL，未输血。患者麻醉复苏后返回病房，术后住院观察1 d出院，患者无不适。

2.2　病例2

2.2.1　一般资料　患者，女，26岁，因“正畸治疗时支抗钉不慎滞留左上颌1 d”就诊。患者诉1 d前于外院行正畸治疗，支抗钉植入过程中，不慎滑脱并滞留。

2.2.2　查体　左上颌区局部触痛，伴轻度张口



a-c: on the preoperative maxillofacial CT cross section, the yellow circle shows the presence of patchy high-density shadows in the left mandibular subcutaneous soft tissue, the soft tissue in front of the left mandibular protuberantia mentalis, and the right zygomatico-buccal subcutaneous soft tissue, which is considered to be foreign body residue. d: a probe searching for the location of the foreign body in the operative area. e & f: in the navigation software, the probe has been sequentially localized to the foreign body in the soft tissue in front of the left mandibular protuberantia mentalis and in the left mandibular subcutaneous soft tissue, as shown by red arrows. g: sequential location of the foreign body under the navigation system, labeled A, B, and C. h: the specimen is shown after removal of the foreign body from the maxillofacial region. Foreign objects A, B, and C are glass fragments, each with a diameter of approximately 0.8 cm, 0.5 cm, 0.1 cm

Figure 1　A 25-year-old male patient with multiple foreign bodies in the maxillofacial area underwent computer navigation-assisted removal of foreign bodies from the chin and right zygomatic bone

图1　25岁男性颌面部多处异物患者计算机导航辅助下颏部及右颧面部异物取出术

受限。

2.2.3　影像学检查　术前颌面部CT提示左侧支抗钉脱落，位于左侧上颌窦后壁后方-近颅底（图2a、2b）。

2.2.4　诊断　左上颌异物。

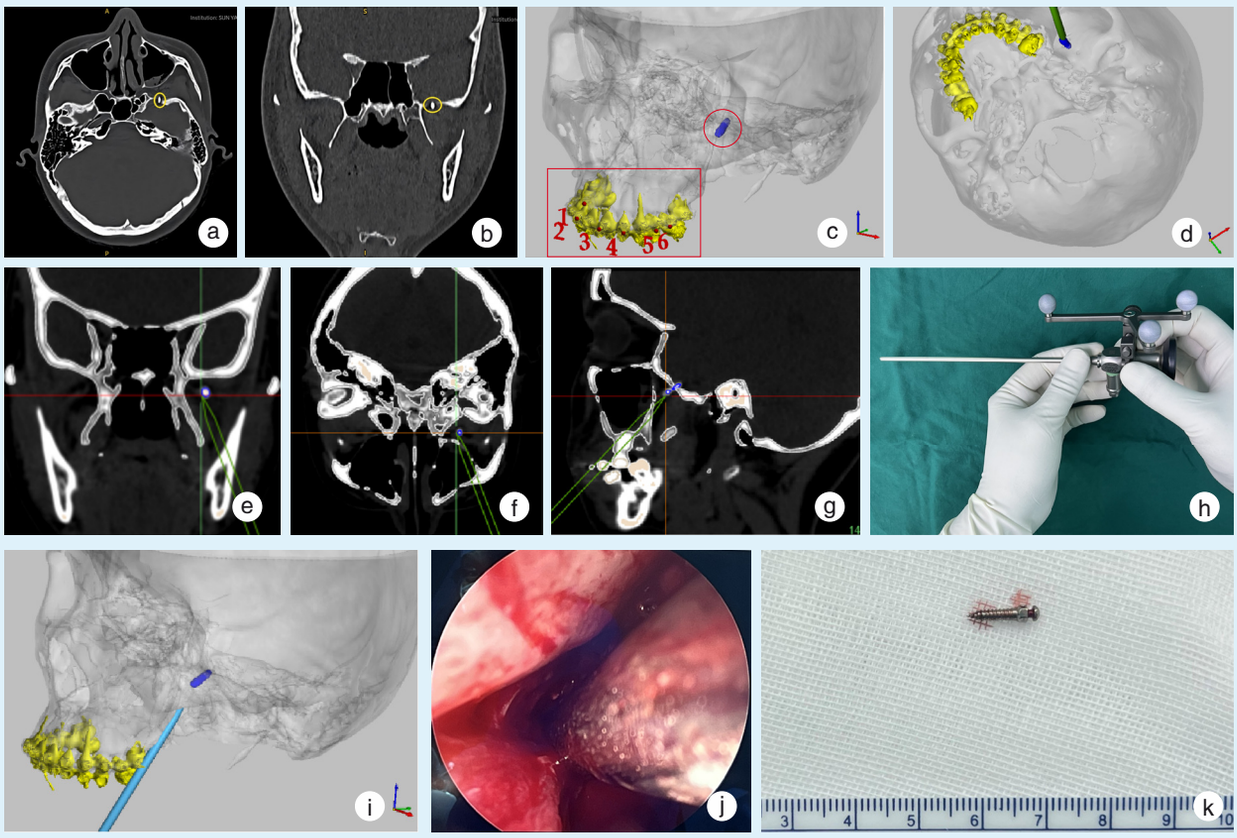
2.2.5　多学科会诊意见　神经外科会诊认为，传统手术入路取出异物存在损伤颅底，导致脑脊液漏的风险，且手术创伤大，仅凭CT影像术中精准定位困难。

2.2.6　治疗计划　为最大限度降低创伤、实现精准操作，决定行内镜联合计算机导航辅助下左上颌异物取出术。

2.2.7　治疗过程与结果　①术前规划：将患者颌面部CT数据导入Mimics软件，三维重建上颌骨并标注异物位置；设计以上颌牙为解剖标志的配准点（图2c）。②术中操作：患者全身麻醉后，取平卧位，常规消毒铺巾；采用头带将计算机导航参考架固定于颅骨，完成系统校准与配准；于左上颌第一磨牙区设计长约1 cm的梯形黏膜瓣，翻瓣暴露上颌结节骨面。首先，在计算机导航系统多平面（3D、冠状位、横断位、矢状位）实时视图引导下（图2d~2g），用探针初步精确定位异物。随后，将计算机导航定位功能通过适配器整合至内镜，形成“画中画”双重视野（计算机导航虚拟定位与内镜真实视野），在直视下安全取出异物（图2h~2k）。③术中及术后情况：术区经生理盐水冲洗、充分止血后，填塞明胶海绵并放置引流条，缝合切口；手术历时约2 h 4 min，术中出血约10 mL，未输血。术后患者安返病房，术区肿痛轻微，否认恶心呕吐、颈部僵硬，否认听觉嗅觉异常。术后1个月未见并发症。

3　讨　论

本研究所有病例均在内镜和/或计算机导航辅助下一次性完整取出异物，未见严重并发症，其结果与近年多个单中心或系统综述关于颌面部异物微创、精准取出的结论一致[1-4]。在复杂解剖与重要结构毗邻的前提下，内镜与计算机导航技术可



a-b: cross-sectional (a) and coronal (b) preoperative CT images of the maxillofacial region; the yellow circle shows that the tip of the supporting nail is located behind the left maxillary sinus, near the left side of the skull base. The skull bone is continuous, no bone destruction is seen, and there are no clear signs of fracture. c: in the three-dimensional reconstructed image, the red rectangular box shows that six points on the labiobuccal orthodontic appliance of the maxillary dental tissues were selected as the alignment points. The red circle shows the foreign body near the left side of the skull base. d-g: as can be seen in the 3D reconstructions and different CT slice images, the probe was used for the initial precise positioning of the foreign body by passing through coronal, transverse, and sagittal positions. h: clamped navigational reference frame fixed to the endoscope; i&j: intraoperative navigational and endoscopic dual view displayed on the computer screen; the dark blue icon represents the foreign body; k: postoperative foreign body specimen with a long diameter of approximately 1.1 cm

Figure 2　A 26-year-old female patient with a left maxillary retained foreign body who underwent navigation and endoscopic-assisted removal of a foreign body

图2　26岁女性左上颌滞留异物患者行计算机导航及内镜辅助下异物取出术

显著提升定位准确性与手术安全性，并减少切口长度与组织破坏程度。颌面部异物主要来源于外伤与医源性操作[5-6]。外伤性异物中，穿透性及爆炸相关的复合型颅颌面异物需严密影像学评估与个体化手术方案[7]。医源性异物中，以种植体移位入上颌窦或邻近颅底区最为常见[5,8]；回顾性研究与病例系列提示风险因素包括：骨量不足、骨质疏松、鼻窦气化明显及术中稳定性欠佳等[9-10]。此外，注射针头等器械折断并移位至翼下颌间隙/咽旁间隙间隙虽少见，但潜在风险高，需早期精准定位与取出[11-12]。

影像学精准定位是成功取出的前提。对于疑似颌面部深部异物，CT或CBCT是临床常用的重要检查手段之一，可通过调整窗宽窗位优化不同材质异物的显示[13]。CBCT空间分辨率高，但对软组织对比度有限[13]。对玻璃、金属等高密度异物检出率高；而木刺等有机物在早期CT上可能显影不清，需注意其CT值随时间变化的特性，必要时重复扫描[14-15]。此外，研究提示床旁或术中超声在浅表软组织、非放射不透（如木刺、塑料）异物定位中有一定辅助价值，但受操作者经验影响较大[16-18]。

近年来，计算机导航技术结合CT或术中CBCT已成为重要辅助手段，它能实时更新异物位置、验证手术路径，避免盲目探查，在深部或小型异物取

出中显示出提升成功率、降低并发症的优势[2-3,19]。此外低剂量术中CBCT方案，可在关键节点进行三维核对，避免二次手术[19-20]。本研究中通过术中精准配准，同样实现了“实时引导-路径验证-完整取出”的流程，验证了该技术的有效性。

然而，下颌骨的可动性仍是影响计算机导航精度的主要挑战，易导致影像与实体不匹配[21]。为提高精度，学者们提出了多种策略：①使用殆垫结合自动配准以稳定下颌；②应用患者特异性动态参考架或混合追踪技术；③与混合现实（mixed reality，MR）/增强现实（augmented reality，AR）平台联动，减少术者视线切换[21-25]。本研究在优化手术计算机导航流程、提升计算机导航精度方面，提出了两项流程优化措施：第一，采用改良版参考架，将参考架放置于上、下颌牙槽骨上，进一步靠近术区；改良的支架臂具有多段关节，避免术区计算机导航时参考架对术区遮挡；第二，将内镜视野与计算机导航影像融合，提供双重直视。这些改进取得了满意的临床效果。

需要指出，当前该领域的证据多来自回顾性研究，高质量前瞻性对照研究相对不足。此外，下颌计算机导航在精度提升、流程标准化及成本控制方面仍需进一步探索[21,23,26]

综上，内镜与计算机导航技术的联合应用，为颌面部异物取出提供了一种高效、精准、微创的解决方案，具有明确的临床推广应用价值。

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