[DOI]10.12016/j.issn.2096-1456.2022.12.006

·防治实践·

金属𬌗面与应力中断设计在𬌗龈距不足游离端牙齿缺失修复中的应用

罗景庭[1]，　王煜民[2]，　孙冠阳[3]，　秦甜[4]，　吴国锋[5]，　巴睿恺[6]
1. 第四军医大学基础医学院三大队九队，陕西 西安(710032)；　2. 第四军医大学基础医学院三大队十二队，陕西 西安(710032)；　3. 新乡医学院附属第83医院口腔科，河南 新乡(453000)；　4. 济南市口腔医院修复科，山东 济南(250000)；　5. 南京大学医学院附属口腔医院修复科，江苏 南京(210008)；　6. 军事口腔医学国家重点实验室，国家口腔疾病临床医学研究中心，陕西省口腔疾病重点实验室，第四军医大学口腔医院修复科，陕西 西安(710032)

【摘要】 目的　探讨金属𬌗面与应力中断设计修复𬌗龈距不足患者游离端牙齿缺失的效果。**方法**　对利用vitallium2000plus结合金属𬌗面、应力中断设计与压力印模技术修复𬌗龈距不足游离端牙齿缺失的病例1例进行回顾性分析，并复习相关文献。**结果**　该金属𬌗面及应力中断设计有效解决了患者𬌗龈距不足、咬合力大、义齿易折裂的难题。应力中断设计可有效保护基牙，但应力中断设计与应力传导现象在患者口内是如何表现的，尚未见报道。本研究T-scan检测结果显示，戴牙前、后，患者𬌗力分配比由左侧77.5%、右侧22.5%变为左侧61.3%、右侧38.7%，右侧牙列𬌗力占总𬌗力分配比提高了16.2%，口内咬合力分布更加均匀。进一步分析，初始咬合阶段，左右侧咬合力基本接近，随着咬合力进一步增加，在中间咬合阶段，右侧咬合力占比有所下降，并在终末咬合阶段进一步下降并达到一个动态平衡。以上T-scan检测及文献复习结果提示咬合力的动态平衡现象与应力中断设计和应力传导有关。**结论**　金属𬌗面复合应力中断设计能够实现对于𬌗龈距不足患者游离端牙齿缺失的微创修复。

【关键词】 可摘局部义齿；　应力中断；　金属𬌗面；　vitallium2000plus；　微创修复；　压力印模；　游离端牙齿缺失；　𬌗龈距不足
【中图分类号】 R78　**【文献标志码】** A　**【文章编号】** 2096-1456(2022)12-0871-07
【引用著录格式】 罗景庭, 王煜民, 孙冠阳, 等. 金属𬌗面与应力中断设计在𬌗龈距不足游离端牙齿缺失修复中的应用[J]. 口腔疾病防治, 2022, 30(12): 871-877. doi:10.12016/j.issn.2096-1456.2022.12.006.

微信公众号

Application of a metal occlusal surface and split framework in the treatment of a patient with mandibular distal extension absence and insufficient occlusogingival distance

LUO Jingting[1], WANG Yumin[2], SUN Guanyang[3], QIN Tian[4], WU Guofeng[5], BA Ruikai[6].　1. 9th Teams, Third Brigade, College of Basic Medicine, the Fourth Military Medical University, Xi'an 710032, China;　2. 12nd Teams, Third Brigade, College of Basic Medicine, the Fourth Military Medical University, Xi'an 710032, China;　3. Department of Stomatology, the 83rd Affiliated Hospital of Xinxiang Medical College, Xinxiang 453000, China;　4. Department of Prosthodontics, Jinan Stomatological Hospital, Jinan 250000, China;　5. Department of Prosthodontics, Nanjing Stomatological Hospital, Medical School of Nanjing University, Nanjing 210008, China;　6. State Key Laboratory of Military Stomatology, National Clinical Research Center for Oral Diseases, Shaanxi Key Laboratory of Stomatology, Department of Prosthodontics, School of Stomatology, the Fourth Military Medical University, Xi'an 710032, China
Corresponding author: BA Ruikai, Email: baruikai880714@126.com; Tel: 86-29-84772453; WU Guofeng, Email: wgffm-

【收稿日期】2022-04-26；　**【修回日期】**2022-07-06
【基金项目】国家自然科学基金项目(81600830)；陕西省自然科学基金青年项目(2017JQ8035)
【作者简介】罗景庭，医师，学士，Email：1293575430@qq.com；共同第一作者，王煜民，医师，学士，Email：3178645521@qq.com
【通信作者】巴睿恺，主治医师，博士，Email：baruikai880714@126.com，Tel：86-29-84772453；共同通信作者，吴国锋，主任医师，博士，Email：wgffmmu@sina.com，Tel: 86-25-83620262

mu@sina.com, Tel: 86-25-83620262

【Abstract】 **Objective** To investigate the effect of a metal occlusal surface and stress interruption design on minimally invasive prosthodontics for patients with distal extension absence and insufficient occlusal gingival distance. **Methods** We retrospectively studied the case of minimally invasive prosthodontic (Vitallium 2000) combined with a metal occlusal surface for distal extension absence in a patient with insufficient occlusal gingival distance; the stress breaking design and pressure impression technology are examined, and relevant articles are reviewd. **Results** The design effectively solves the problems of insufficient occlusal gingival distance, large occlusal force and easy denture fracture. Reviewing the relevant literature, stress interruption design can effectively protect abutment teeth, but the behavior of stress interruption design and stress conduction phenomena in the mouths of patients has not been reported. The T-scan test results of this study showed that before and after wearing the denture, the occlusal force distribution ratio of the patient changed from 77.5% on the left and 22.5% on the right to 61.3% on the left and 38.7% on the right. The occlusal force distribution ratio of the right dentition to the total occlusal force increased by 16.2%, and the occlusal force became better distributed. Further analysis showed that the occlusal forces on the left and right sides were nearly the same in the initial occlusion stage. As the occlusal force was further increased, the proportion of the occlusal force on the right side decreased in the middle of the occlusion stage and further decreased in the final occlusion stage until it reached a dynamic balance. The above T-scan test and literature review results suggest that this dynamic balance phenomenon of bite force is related to the stress interruption design and the stress conduction effect of the split framework. **Conclusion** The composite of stress interruption design and metal occlusal surface allows for minimally invasive prosthodontics for the treatment of distal extension absence in patients with insufficient occlusal gingival distance.

【Key words】 removable partial denture; stress interruption; metal occlusal surface; vitallium2000plus; minimally invasive prosthodontics; pressure impression; distal-extension absence; insufficient occlusal gingival distance
J Prev Treat Stomatol Dis, 2022, 30(12): 871-877.
【Competing interests】 The authors declare no competing interests.
This study was supported by the grants from National Natural Science Foundation of China (No. 81600830); Shaanxi Provincial Natural Science Foundation Youth Project (No. 2017jq8035).

长期牙列缺损会导致患者语言、面容、咀嚼等生理功能的异常，对患者的生理和心理造成不同程度的影响[1-2]。远中游离端牙齿缺失是牙列缺损的常见类型之一。以往有研究表明，远中游离端牙齿缺失在牙列缺损比例中约占到19.51%[2-3]。目前，可摘局部义齿修复在临床上仍是游离端牙齿缺失的主要修复方式[4-6]。但是，患者长期缺牙导致对颌牙伸长以及以往治疗中对伸长牙的过度调磨，均给游离端牙齿缺失患者的修复治疗带来极大困难[7-8]。另外，在游离端可摘局部义齿应用过程中，由于基牙与黏膜组织之间存在的应力应变差异，会造成义齿游离端下沉，基牙损伤，这些也都为游离端牙齿缺失患者的治疗工作带来不小的难度[9-10]。研究显示RPI卡环组和应力中断设计能够有效保护游离端牙齿缺失患者的邻缺隙基牙[11]。本文报告1例𬌗龈距不足、对颌牙伸长且被多次调磨致牙本质暴露的游离端牙齿缺失患者的治疗，应用vitallium2000plus结合金属𬌗面、应力中断设计与压力印模技术，在保留被多次调磨的对颌余留牙活髓前提下，有效解决了患者𬌗龈距不足、咬合力大、义齿易折裂的难题，并利用T-scan观察到义齿发挥咀嚼功能时的应力中断与应力传导现象，为今后义齿设计提供参考并为相关后续研究提供思路。

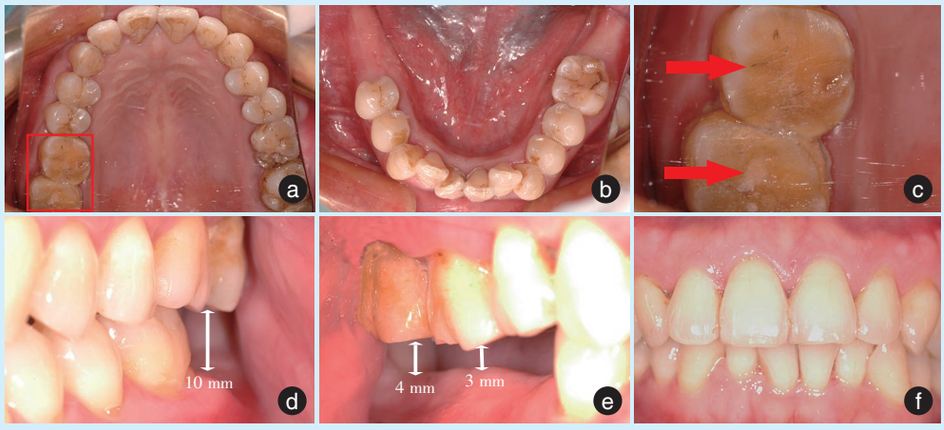
1　资料和方法

1.1　病例资料

患者，女性，51岁，陕西西安人，因双侧下颌后牙缺失3年，来我院要求修复治疗。患者无吸烟、酗酒史。全身健康状况良好，否认有高血压、心脏病等系统性疾病，否认有乙肝、艾滋病等传染性疾病，无药物过敏史。患者自述“5年前两侧下后牙因严重龋坏于外院拔除，曾于外院行活动义齿修复2次，均半年内折断。最近一次活动义齿损坏至今1年时间内，未对缺失牙进行修复。以往修复过程中曾因缺牙区对颌牙伸长，对右侧上后牙进行调磨，右侧上后牙进食过冷过热食物有不适感”。临床检查：37牙缺失，邻缺隙牙无倾斜、无扭转，对

颌牙无明显伸长，咬合间隙良好。缺牙区牙槽骨低平，无明显骨尖，黏膜正常。46、47牙缺失，邻缺隙牙无倾斜、无扭转，45牙Ⅰ度松动。对颌16、17牙伸长，并已行调磨，牙本质暴露，探之有牙本质敏感症状，缺牙间隙约3～4 mm。缺牙区牙槽骨丰满，无明显骨尖，黏膜正常（图1）。正中𬌗关系，开口度、开口型正常，无关节弹响等颞下颌关节症状。

影像学检查显示：患者右侧缺牙区牙槽嵴丰满，对颌牙伸长，𬌗龈距不足（图2）。临床诊断：37、46、47牙齿缺失。



a: the right maxillary first and second molars had been ground (as blank indicated); b: the alveolar ridge of the mandibular edentulous area was plump; c: the dentin of the right maxillary first and second molars was exposed (arrows); d: the left edentulous space was approximately 10 mm; e: the right edentulous space was approximately 3-4 mm; f: centric occlusion

Figure 1　Oral examination of a mandibular distal-extension absence patient with insufficient occlusal gingival distance

图1　𬌗龈距不足下颌游离端牙齿缺失患者口内检查情况

1.2　治疗计划

针对该病例𬌗龈距不足、修复空间有限的难题，结合患者保留对颌牙活髓、微创不增加口腔外科手术、义齿耐用的要求，对患者进行脱敏治疗后针对性地制定出3个对策。

首先，为解决修复空间有限的问题，设计金属𬌗面及颊面树脂雕牙；其次，为防止义齿游离端过度下沉、支架断裂，对缺牙区采用局部功能性印模；最后，为合理分散𬌗力，保护基牙，对支架进行应力中断设计。

治疗计划：可摘局部义齿修复缺失牙。

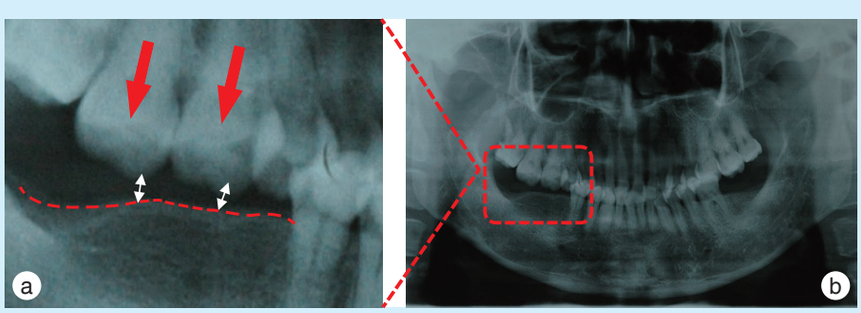
1.3　治疗过程

1.3.1　初模型分析与支架设计　取初模型，利用导线观测仪进行分析，进行义齿初步设计，完成义齿设计图（图3）。

1.3.2　基牙预备与精细印模　依据义齿就位道方向制备备牙导板，并利用备牙导板进行基牙预备，消除基牙过大倒凹，制备导平面及支托窝。并用个别托盘与流动性更好的聚醚橡胶，两步法制取精细印模（图4）。

1.3.3　𬌗关系转移　利用面弓完成𬌗关系的记录与转移，并完成工作模型上𬌗架。再次与技师交流，明确支托、卡环、大连接体的形式与位置，金属𬌗面、网状加强以及应力中断设计，并共同在工作模型上完成义齿制作图（图5）。

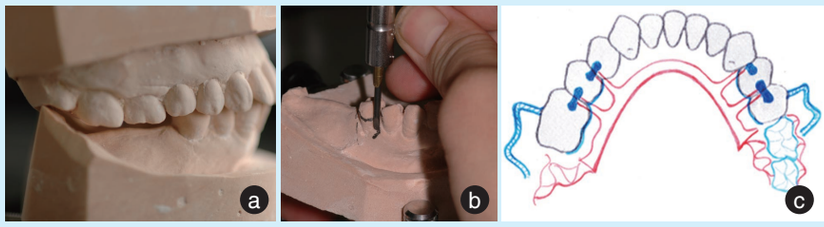
1.3.4　功能性印模　1周后复诊，支架调改，口内



a: the alveolar ridge in the right edentulous area was plump; b: the right maxillary first and second molar extended so that the edentulous space was limited

Figure 2　Imaging examination of a mandibular distal - extension absence patient with insufficient occlusal gingival distance

图2　𬌗龈距不足下颌游离端牙齿缺失患者影像学检查



a: the preliminary stone model showed that the right edentulous space was limited; b: drew the survey line; c: the design of the framework

Figure 3　Analysis of preliminary stone model and design of the framework

图3　初模型分析与支架设计

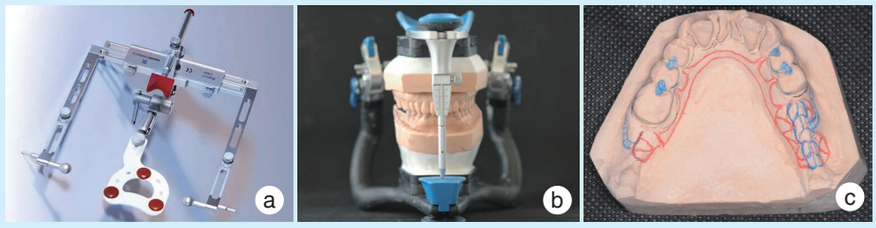
a: teeth preparation guide plate was made according to the direction of denture insertion path; b: prepared the guide plane of abutment teeth according to the instruction of positioning needle; c: achieved the precise impression using polyether rubber by two-step method

Figure 4　Preparation of abutment teeth and precise impression

图4　基牙预备与精细印模

试戴合适后，用光敏树脂在支架上制作缺牙区局部个别托盘，并进行边缘整塑，利用聚醚橡胶制取功能性印模后，进行模型切割、围模灌注及模型修整。重新上架后，送交技工室（图6）。

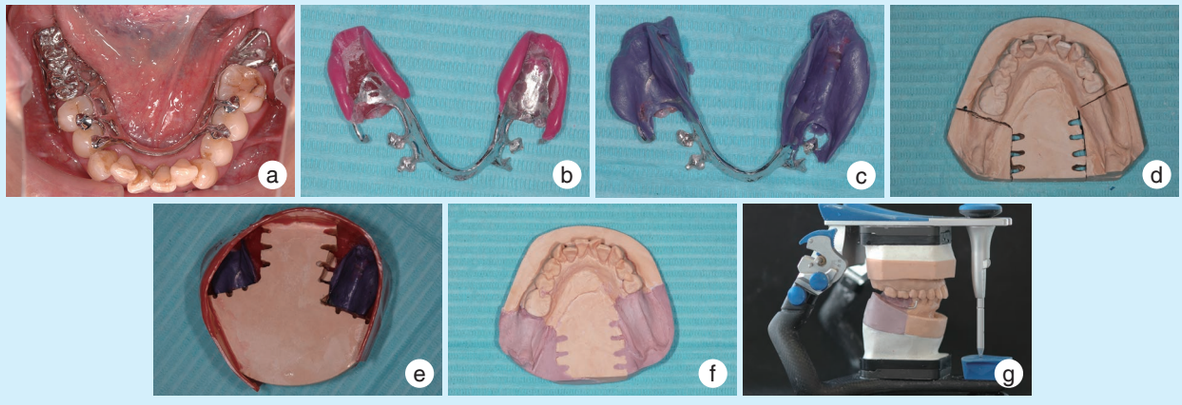
1.3.5　义齿完成与试戴　义齿初戴时，首先对义齿组织面、基托边缘进行调磨。义齿完全就位后，用



a: the facial bow was used to record and transfer the occlusal relationship; b: the final stone model was placed in the articulator; c: drew the design on the stone model

Figure 5　Occlusal relationship transfer

图5　𬌗关系转移



a: framework try-in; b: boder molding; c: pressure impression; d: cutting the stone model; e: boxing pouring; f: cast trimming; g: remounting articulator

Figure 6　Functional impression

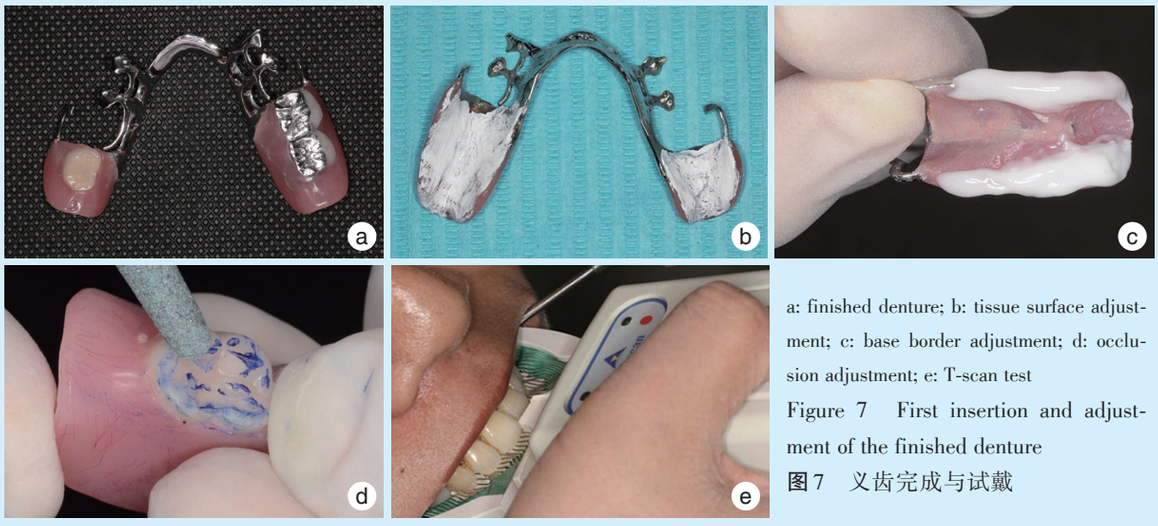
图6　功能性印模

咬合纸辅助进行咬合调改。T-scan检测调改后患者口内咬合状态(图7)。

2　结　果

口内照显示,金属𬌗面复合颊侧树脂雕牙的设计既有效解决了缺牙间隙过小的问题,又满足了患者对义齿轻便、美观的要求。患者6个月复诊时,对修复效果表示非常满意。为进一步研究患者咬合稳定后口内咬合状态,为患者进行了5次T-scan检测,结果一致。T-scan检测显示,与未戴义齿时咬合状况(左侧77.5%,右侧22.5%)相比,戴牙后患者𬌗力分配比变为左侧61.3%,右侧38.7%,右侧牙列𬌗力占总𬌗力分配比提高了16.2%,口内咬合力分布更加均匀,有效提高了患者口内咬合力分布的合理性(图8)。

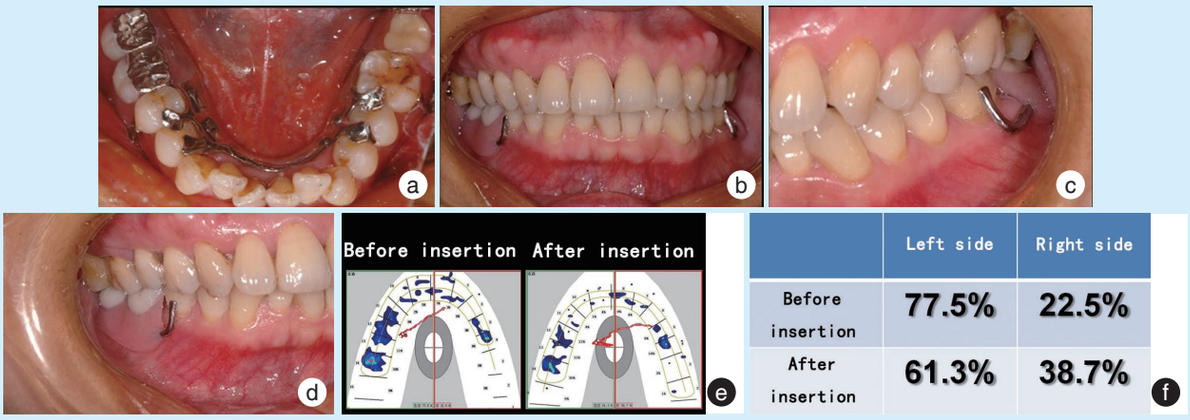
进一步研究患者戴牙后的T-scan检测结果显示:咬合过程中,初始咬合状态左右侧咬合力分配比为47.6%∶52.4%,此时右侧第一磨牙所分担𬌗力占总𬌗力的13%;随着咬合力进一步增大,右侧第一磨牙所分担𬌗力占总𬌗力的比例下降到8%,左右侧咬合力分配比为53.4%∶46.6%;到终末咬合阶段,右侧第一磨牙所分担𬌗力占总𬌗力的比例下降到2%,此时左右牙列咬合力分配比达到了61.3%∶38.7%的动态平衡(图9)。



a: finished denture; b: tissue surface adjustment; c: base border adjustment; d: occlusion adjustment; e: T-scan test

Figure 7　First insertion and adjustment of the finished denture

图7　义齿完成与试戴



a: denture try-in; b: centric occlusion after insertion; c: left occlusion after insertion; d: right occlusion after insertion; e: T-scan test showed that occlusal force became more uniform after insertion; f: the distribution ratio of right occlusal force to total occlusal force increased by 16.2%, and the distribution of occlusal force was more uniform, which effectively improved the rationality of the distribution of occlusal force

Figure 8　Intraoral images after insertion and comparison of occlusion before and after insertion

图8　戴牙后口内照及戴牙前后咬合力分布对比

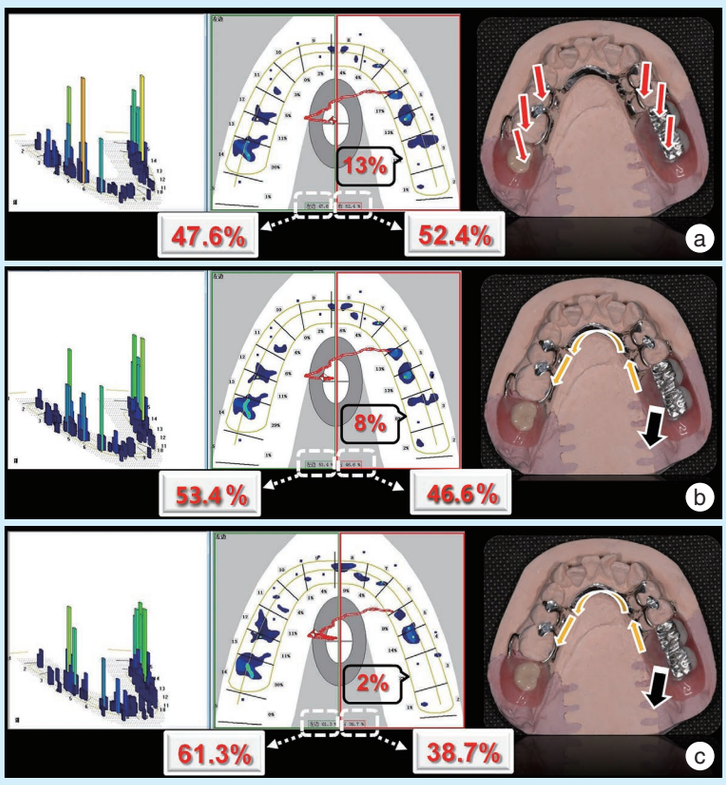


Figure 9　Distribution ratio of occlusal force at different stages of occlusion

图9　不同咬合阶段咬合力分配比变化

a: in the initial occlusal state, the distribution ratios of the left and right occlusal forces were 47.6% to 52.4%. At this time, the occlusal force shared by the right first molar accounted for 13% of the total occlusal force, and red arrows indicate occlusal force. b: as the occlusal force was further increased, the occlusal force shared by the right first molar decreased to 8% due to occlusal force transmission. Yellow arrows indicate the resilience of the material, and the stress interruption design of the framework released the right occlusal force in the middle and final stages of occlusion and transmitted it to the front and the opposite side through the framework. The black arrow indicates that the base transmitted the occlusal force to the alveolar ridge along the vertical direction. c: at the final stage of occlusion, the occlusal force shared by the right first molar decreased to 2%. At this time, the occlusal force of the left and right dentition reached a dynamic balance of 61.3% to 38.7%. Yellow arrows indicate the resilience of the material, and the stress interruption design of the framework released the right occlusal force in the middle and final stages of occlusion and transmitted it to the front and the opposite side through the framework. The black arrow indicates that the base transmitted the occlusal force to the alveolar ridge along the vertical direction

3　讨　论

肯氏Ⅰ类牙列缺损是口腔修复临床多发病、常见病，可摘局部义齿仍然是其主要修复方式。天然牙与黏膜混合支持形式及基牙与黏膜不同的可让性，决定了刚性铸造支架受力不均衡时会造成基牙的牙周损伤甚至松动[12]。为改善传统义齿基牙受力方式，Knapp等[13]提出应力中断式可摘局部义齿支架，其所采用的分裂式义齿设计使咬合力更加合理地分散到基牙与黏膜上，同时分散到整个支架上。以往文献回顾发现，应力中断式义齿设计可以明显减少基牙松动度，有助于维护邻缺隙基牙的牙周健康[14-15]。Vitallium2000plus是一种新型钴铬钼合金（钴63.4%、铬29%、钼5.2%），具有良好的生物安全性[16]，维氏硬度与牙本质相近，保证耐磨强度的同时不会使对颌牙产生过度的磨耗。该患者由于对颌牙伸长，在以往治疗过程中多次被调磨并且已出现牙本质暴露，同时牙槽嵴丰满导致𬌗龈距不足，因此，为有效保存对颌牙的活髓，设计了金属𬌗面复合树脂雕牙，既有效解决了缺牙间隙过小的问题，又满足了患者对义齿轻便、美观的要求。同时针对磨牙区咬合力较大、义齿易折断的问题，对患者进行了功能性印模，获得缺牙区牙槽嵴黏膜组织在功能受压状态下的模型，减少了义齿在咬合状态下的下沉移位，同时利用Vitallium2000plus材料良好的屈服强度（680 MPa）和拉伸强度（960 MPa），提高义齿支架抵抗永久形变与折裂的能力。

有学者研究发现，可摘局部义齿的应力中断设计，能够使人工牙上承担的咀嚼力通过近中支托垂直向传递至基牙上，基牙不受其他扭力，从而有效保护基牙[17]。但应力中断与应力传导现象在患者口内是如何表现的，尚未见报道。通过T-scan对本病例的咬合状态分析，发现戴牙前、后，患者𬌗力分配比由左侧77.5%、右侧22.5%变为左侧61.3%、右侧38.7%，右侧牙列𬌗力占总𬌗力分配比提高了16.2%，口内咬合力分布更加均匀，有效提升患者口内咬合力分布的合理性。通过进一步研究，发现了一个更有趣的现象：初始咬合阶段，左右侧咬合力基本接近，随着咬合力进一步增加，在中间咬合阶段右侧咬合力占比有所下降，并在终末咬合阶段进一步下降并达到一个动态平衡。分析此现象与应力中断设计和支架应力传导作用有

关，材料的回弹力与支架的应力中断设计使右侧咬合力在咬合中间和终末阶段有所释放并通过支架向前部和对侧传导，同时基托沿垂直方向传导𬌗力于牙槽嵴，保护邻缺隙基牙的同时，生理性刺激还能对牙槽嵴起到间接保护作用。受样本量限制，本病例研究主要为类似的𬌗龈距不足患者的修复方法提供参考，关于应力传导的机制研究，后期会做进一步的大样本研究。

【Author contributions】 Luo JT, Wang YM collected, analyzed the data and revised the article. Sun GY, Qin T analyzed the data and revised the article. Wu GF designed the study and revised the article. Ba RK designed the study and wrote the article. All authors read and approved the final manuscript as submitted.

参考文献

[1] Kurosaki Y, Kimura-Ono A, Mino T, et al. Six-year follow-up assessment of prosthesis survival and oral health-related quality of life in individuals with partial edentulism treated with three types of prosthodontic rehabilitation[J]. J Prosthodont Res, 2021, 65(3): 332-339. doi: 10.2186/jpr.JPR_D_20_00095

[2] Ali Z, Baker SR, Shahrbaf S, et al. Oral health-related quality of life after prosthodontic treatment for patients with partial edentulism: a systematic review and meta-analysis[J]. J Prosthet Dent, 2019, 121(1): 59-68. doi: 10.1016/j.prosdent.2018.03.003

[3] Arita S, Gonda T, Togawa H, et al. Influence of mandibular distal extension implant-supported removable partial dentures on the force exerted on maxillary anterior teeth[J]. J Prosthodont Res, 2021, 65(4): 541-545. doi: 10.2186/jpr.JPR_D_20_00077.

[4] Inukai M, Baba K, John MT, et al. Does removable partial denture quality affect individuals´ oral health?[J]. J Dent Res, 2008, 87(8): 736-739. doi: 10.1177/154405910808700816.

[5] Park JH, Lee JY, Shin SW, et al. Effect of conversion to implant-assisted removable partial denture in patients with mandibular Kennedy classification: a systematic review and meta-analysis[J]. Clin Oral Implants Res, 2020, 31(4): 360-373. doi: 10.1111/clr.13574.

[6] Yunizar MF, Watanabe M, Ichikawa T. Current development status of additive manufacturing technologies for fabricating removable partial denture frameworks: a literature review[J]. Int J Comput Dent, 2022, 25(1): 57-70.

[7] MyintOo KZ, Fueki K, Yoshida-Kohno E, et al. Minimal clinically important differences of oral health-related quality of life after removable partial denture treatments[J]. J Dent, 2020, 92: 103246. doi: 10.1016/j.jdent.2019.103246.

[8] Vozza I, Manzon L, Passarelli PC, et al. The effects of wearing a removable-partial-denture on the bite forces: a cross-sectional study [J]. Int J Environ Res Public Health, 2021, 18(21): 11401. doi: 10.3390/ijerph182111401.

[9] Watanabe C, Wada J, Mizutani K, et al. Chronological grey scale changes in supporting alveolar bone by removable partial denture placement on patients with periodontal disease: a 6-month follow-up study using digital subtraction analysis[J]. J Dent, 2017, 63: 8-13. doi: 10.1016/j.jdent.2017.05.004.

[10] Kuralt M, Bukleta MS, Kuhar M, et al. Bone and soft tissue changes associated with a removable partial denture. A novel method with a fusion of CBCT and optical 3D images[J]. Comput Biol Med, 2019, 108: 78-84. doi: 10.1016/j.compbiomed.2019.03.024.

[11] Rungsiyakull C, Rungsiyakull P, Suttiat K, et al. Stress distribution pattern in mini dental implant-assisted RPD with different clasp designs: 3D finite element analysis[J]. Int J Dent, 2022: 2416888. doi: 10.1155/2022/2416888.

[12] Harb IE, Abdel-Khalek EA, Hegazy SA. CAD/CAM constructed poly (etheretherketone) (PEEK) framework of Kennedy Class I removable partial denture: a clinical report[J]. J Prosthodont, 2019, 28(2): e595-e598. doi: 10.1111/jopr.12968.

[13] Knapp JG, Shotwell JL, Kotowicz WE. Technique for recording dental cast-surveyor relations[J]. J Prosthet Dent, 1979, 41(3): 352-354. doi: 10.1016/0022-3913(79)90023-4.

[14] Mousa MA, Abdullah JY, Jamayet NB, et al. Biomechanics in removable partial dentures: a literature review of FEA-based studies [J]. Biomed Res Int, 2021: 5699962. doi: 10.1155/2021/5699962.

[15] Chen X, Mao B, Zhu Z, et al. A three-dimensional finite element analysis of mechanical function for 4 removable partial denture designs with 3 framework materials: CoCr, Ti-6Al-4V alloy and PEEK[J]. Sci Rep, 2019, 9(1): 13975. doi: 10.1038/s41598-019-50363-1.

[16] Wang W, Li T, Luo X, et al. Cytotoxic effects of dental prosthesis grinding dust on RAW264.7 cells[J]. Sci Rep, 2020, 10(1): 14364. doi: 10.1038/s41598-020-71485-x.

[17] 崔嘉玺, 谭力芯, 熊宇, 等. 应力中断式附着体义齿修复下颌双侧游离端缺失的生物力学分析[J]. 中国美容医学, 2017, 26(3): 25-28. doi: 10.15909/j.cnki.cn61-1347/r.001627.
Cui JX, Tan LX, Xiong Y, et al. Biomechanical analysis of the mandibular bilateraI-distal extension absence restored with a stress-breaking attachment retained removabalepartiaI denture[J]. Chin J Aesthet Med, 2017, 26(3): 25-28. doi: 10.15909/j.cnki.cn61-1347/r.001627.

（编辑　张琳，管东华）

官网