

[DOI] 10.12016/j.issn.2096-1456.2024.05.006

· 临床研究 ·

隐形矫治器远移成年患者上颌磨牙疗效的 Meta 分析

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【摘要】 目的 评价无托槽隐形矫治器远中移动成年患者上颌磨牙的临床疗效, 以提高正畸医生对疗效的预估性。**方法** 检索 Web of Science、The Cochrane Library、Embase、Pubmed、万方数据库、知网数据库、维普数据库公开发表的隐形矫治器远移成年患者上颌磨牙疗效的研究。检索时限为建库以来至 2023 年 8 月 1 日。共 3 名研究者进行文献筛选及质量评估, 将满足质量标准的文献进行 Meta 分析。**结果** 本研究共纳入 13 个前后对照试验, 总样本量 281 例。Meta 分析结果显示, 治疗后颌骨矢状向及垂直向指标与治疗前相比差异无统计学意义 ($P > 0.05$); 治疗后上颌第一磨牙远中移动量 $MD = -2.34$, $95\%CI (-2.83, -1.85)$, 压低移动量 $MD = -0.95$, $95\%CI (-1.34, -0.56)$, 远中倾斜量 $MD = -2.51$, $95\%CI (-3.56, -1.46)$, 与治疗前相比差异均有统计学意义 ($P < 0.05$); 治疗后上颌切牙平均内收距离 $MD = -0.82$, $95\%CI (-1.54, -0.09)$, 唇倾度减小 $MD = -1.61$, $95\%CI (-2.86, -0.36)$, 与治疗前相比差异均有统计学意义 ($P < 0.05$)。**结论** 隐形矫治器能够有效远中移动上颌磨牙并控制磨牙垂直向位置, 磨牙远移的同时伴有一定的压低及远中倾斜移动, 对高角型患者有利。上颌切牙的矢状向内收有利于患者侧貌的改善。

【关键词】 Meta 分析; 隐形矫治器; 磨牙远移; 正畸; 错殆畸形; 安氏 II 类; 牙齿移动; 切牙内收

【中图分类号】 R78 **【文献标志码】** A **【文章编号】** 2096-1456(2024)05-0367-09

【引用著录格式】 康芙嘉, 李欣鹏, 张茜雅, 等. 隐形矫治器远移成年患者上颌磨牙疗效的 Meta 分析[J]. 口腔疾病防治, 2024, 32(5): 367-375. doi:10.12016/j.issn.2096-1456.2024.05.006.

Meta-analysis of the efficacy of invisible orthodontic appliances for maxillary molar distalization in adult patients KANG Fujia¹, LI Xinpeng¹, ZHANG Xiya², SHI Xinning¹, CHANG Luguangda¹, ZHU Xianchun¹. 1. Department of Orthodontics, Hospital of Stomatology, Jilin University, Changchun 130021, China; 2. School of Stomatology, Yanbian University, Yanbian 133002, China

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【Abstract】 Objective To evaluate the clinical efficacy of invisible orthodontic appliances without brackets for the distal movement of maxillary molars to improve the ability of orthodontists to predict treatment outcomes. **Methods** Web of Science, Cochrane Library, Embase, PubMed, Wanfang Database, CNKI Database, and VIP Database were searched for studies investigating the efficacy of invisible orthodontic appliances for distal movement of maxillary molars in adult patients and published from database inception to August 1, 2023. A total of three researchers screened the studies and evaluated their quality and conducted a meta-analysis of those that met quality standards. **Results** This study included 13 pre- and postcontrol trials with a total sample size of 281 patients. The meta-analysis revealed no significant differences in the sagittal or vertical parameters of the jawbone after treatment when compared with those before treatment ($P > 0.05$). The displacement of the first molar was $MD = -2.34$, $95\% CI (-2.83, -1.85)$; the displacement was $MD = -0.95$, $95\% CI (-1.34, -0.56)$; and the inclination was $MD = -2.51$, $95\% CI (-3.56, -1.46)$. There was a statistically

【收稿日期】 2023-09-14; **【修回日期】** 2023-11-20

【基金项目】 吉林省自然科学基金(YDZJ202201ZYT057); 吉林省科技厅科技发展计划项目(20210203064SF)

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significant difference in the change in sagittal, vertical, and axial tilt of the first molar before and after treatment. After treatment, the average adduction distance of the incisors was $MD=-0.82$, 95% $CI (-1.54, -0.09)$, and the decrease in lip inclination was $MD=-1.61$, 95% $CI (-2.86, -0.36)$; these values were significantly different from those before treatment ($P < 0.05$). **Conclusion** Invisible orthodontic appliances can effectively move the upper molars in a distal direction and control the vertical position of the molars. When the molars move further away, there is some degree of compression and distal tilt movement, which is beneficial for patients with high angles. The sagittal movement of incisors is beneficial for improving the patient's profile.

【Key words】 Meta-analysis; invisible appliance; molar distalization; orthodontics; malocclusion; Angle Class II malocclusion; teeth movement; incisor adduction

J Prev Treat Stomatol Dis, 2024, 32(5): 367-375.

【Competing interests】 The authors declare no competing interests.

This study was supported by Jilin Provincial Natural Science Foundation (No. YDZJ202201ZYTS057); Jilin Provincial Department of Science and Technology Science and Technology Development Plan Project (No. 20210203064SF).

上颌磨牙远移技术作为非拔牙矫治病例中获取间隙的一种有效方式,能够纠正牙源性安氏Ⅱ类错殆畸形,改善轻度牙列拥挤及侧貌前突。传统矫治手段包括口外装置:口外弓、J钩;口内装置: Pendulum, Distal jet, Jones jig等^[1-8]。以上矫治器舒适性差,异物感强,矫治效果易受到患者依从性影响^[9-11]。随着无托槽隐形矫治器的应用和普及,其相较于传统矫治器的优势也逐渐凸显:材料透明美观,不易被察觉;患者自行摘戴,便于口腔卫生维护;紧密包裹牙齿,对黏膜刺激小^[12-14]。已有大量研究证实无托槽隐形矫治器在磨牙远移的治疗中实现率高^[15-19]。与青少年患者群体相比,成年人生长发育停止,牙弓长度的扩展受到颌骨空间的限制^[20],且部分患者对于侧貌美观具有明确及严格的要求。因此,使用何种手段为临界病例获得间隙还存在一定争议。其次,在磨牙远移的过程中,磨牙远中倾斜移动导致支点后移,可能造成下颌顺旋及高角型患者面型的恶化^[21]。本研究根据现有的临床证据,评估隐适美矫治器进行成年患者上颌磨牙远移的疗效,为临床医生把握适应证及确定矫治方案提供一定的参考依据。

1 资料和方法

本研究已在PROSPERO登记注册(注册号:CRD42023456913)(https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=456913),本研究遵循《Cochrane 干预措施系统评价手册》进行纳入排除标准制定、文献检索、数据分析及报告。

1.1 纳入及排除标准

1.1.1 纳入标准 ①研究对象:成年骨性Ⅰ类及轻

度骨性Ⅱ类患者(年龄18~40岁、 $0^\circ < ANB < 5^\circ$);上颌轻度拥挤,磨牙后区可供远移空间充足;牙齿大小及形态正常,除第三磨牙外无缺失牙齿;依从性良好、每2~3个月能够随访复查;②干预措施:佩戴隐适美矫治器进行上颌磨牙远移治疗;③对照项目:患者治疗前、后自身对照;④结局指标:垂直向、矢状向骨性及牙性测量指标;⑤研究类型:随机对照试验,临床对照试验,前瞻性和回顾性研究以及被认为有资格纳入的研究。

1.1.2 排除标准 ①曾有正畸治疗史或患有牙周疾病、颞下颌关节紊乱等影响正畸疗效的口腔以及全身疾患。②重复发表、数据不全、无法获得全文以及质量差的研究。

1.2 文献检索及筛选

对PubMed、Embase、Web of Science、Scopus、Cochrane Library、Embase、万方、维普及中国知网数据库等进行检索,主要英文检索词包括:clear aligner、Invisalign、invisible appliance、molar distalization、molar backwards;中文检索词包括:隐形矫治器、磨牙远移、推磨牙向后、无托槽矫治器、隐适美。英文数据库检索策略为:#1:clear aligner OR Invisalign OR invisible appliance, #2:molar distalization OR molar backwards, #3:#1 AND #2。中文数据库检索策略为:#1:隐形矫治器 OR 无托槽矫治器 OR 隐适美, #2:推磨牙向后 OR 磨牙远移, #3:#1 AND #2。检索时限为建库以来至2023年8月1日,纳入出版语言为中文及英文的文献,根据各数据库特征调整相应检索式,手动追溯纳入文献的参考文献以补充可能遗漏的文献。全面检索后,使用文献管理软件EndNote X9剔除重复研究。由两

位研究者根据标题及摘要独立进行初步筛选,再根据文献的全文内容确定是否纳入。如有分歧,则由第三位研究者讨论后决定。

1.3 质量评价

由于本研究纳入了前后对照的研究,因此采用非随机临床对照试验的偏倚风险评估 MINORS 量表 (methodological index for non-randomized studies), 其中前 8 条用于评价无对照组的研究。偏倚风险评估由两位研究者独立进行评价并交叉核对,意见不统一时由此两位研究者讨论解决,若仍有争议时由第三位研究者共同参与讨论。

1.4 资料提取

两研究员独立提取纳入文献的资料及数据,提取内容包括文章作者及发表年份、样本容量、受试者一般资料、干预措施、结局指标等。

1.5 统计学分析

采用 RevMan5.4 软件进行 Meta 分析,提取治疗前、后结局指标测量值,根据其变化量评估使用 Invisalign 进行上颌磨牙远移的疗效。由于结局指标为连续性数据,且相同指标的测量单位一致,故选用均数差 (MD) 作为本 Meta 分析的效应量,并计算 95% 可信区间,当 $P < 0.05$ 为差异有统计学意义。异质性检验采用森林图及 I^2 检验:若 $P \geq 0.1$, $I^2 \leq 50\%$, 可认为异质性较低,可选用固定效应模型;若 $P < 0.1$, $I^2 > 50\%$, 分析异质性来源并进行敏感性分析,选择随机效应模型,必要时进行亚组分析或描述性分析。绘制漏斗图、使用 Stata 14 进行

Egger 检验分析发表偏倚。

2 结果

2.1 文献纳入过程及特征提取

两位研究者按上述检索策略初步筛查出 310 篇相关研究,阅读题目及摘要后筛选出与本研究相关的文献共 28 篇,仔细阅读全文后,筛选出 13 篇^[16, 21-32]文献纳入本研究,具体流程见图 1,纳入文献基本特征见表 1,纳入文献质量评估表见表 2。

2.2 Meta 分析结果

2.2.1 颌骨矢状向及垂直向指标变化情况森林图 ①SNA (sella-nasion-subspinale angle, 蝶鞍中心-鼻根点-上牙槽座点角): 共有 10 篇研究测量了

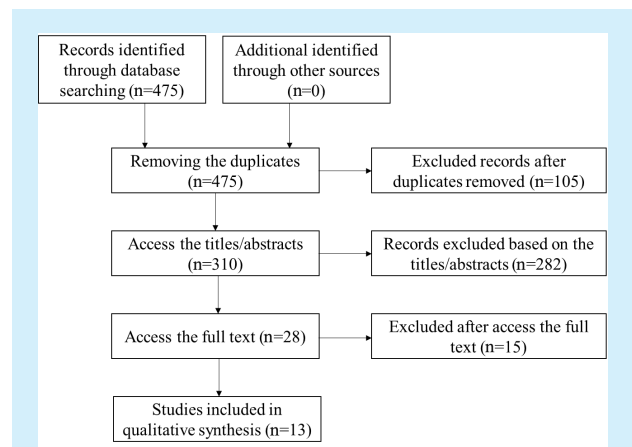


Figure 1 Studies retrieval process

图 1 文献检索流程

表 1 纳入文献的基本特征

Table 1 Basic features of the included studies

	Study design	Sample size	Gender (Male/Female)	Age/year	Attachment	Class II elastic traction	Mini-implant	Course/year	Measuring method
Al-Tayar 2023 ^[23]	Retrospective	23	7/16	29.8 ± 4.6	Valid	Valid	Null	1.97 ± 0.6	CBCT
Xu 2023 ^[27]	Retrospective	67	30/37	20.8 ± 4.9	Rectangular attachment	Null	Valid	Not mentioned	CBCT
Cui 2022 ^[24]	Retrospective	18	Not mentioned	27.8 ± 5.38	Not mentioned	Not mentioned	Not mentioned	Not mentioned	CBCT
Lione 2022 ^[21]	Randomized controlled trial	20	7/13	17.1 ± 3.2	Rectangular attachment	Valid	Null	Not mentioned	Cephalogram
Rongo 2022 ^[26]	Retrospective	20	5/15	27.6 ± 6.3	Not mentioned	Valid	Null	1.6 ± 0.6	Cephalogram
Zhou 2022 ^[28]	Retrospective	15	4/11	27	Not mentioned	Valid	Null	Not mentioned	CBCT
Cheng 2020 ^[29]	Retrospective	11	3/8	27.6 (24-35)	Rectangular attachment	Null	Valid	Not mentioned	CBCT
Caruso 2019 ^[22]	Retrospective	10	2/8	22.7 ± 5.3	Rectangular attachment	Valid	Null	1.9 ± 0.5	Cephalogram
Wu 2019 ^[30]	Retrospective	10	Not mentioned	24	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Cephalogram
Li 2017 ^[31]	Retrospective	11	4/7	25.3 (21-34)	Rectangular attachment	Valid	Null	Not mentioned	Cephalogram
Ravera 2016 ^[16]	Retrospective	20	9/11	29.73 ± 6.89	Rectangular attachment	Valid	Null	2.02 ± 0.35	Cephalogram
Yang 2015 ^[32]	Retrospective	15	5/10	27.7	Valid	Valid	Valid	Not mentioned	CBCT
Klein 2013 ^[25]	Retrospective	28	10/18	35.5	Valid	Valid	Null	Not mentioned	Cephalogram

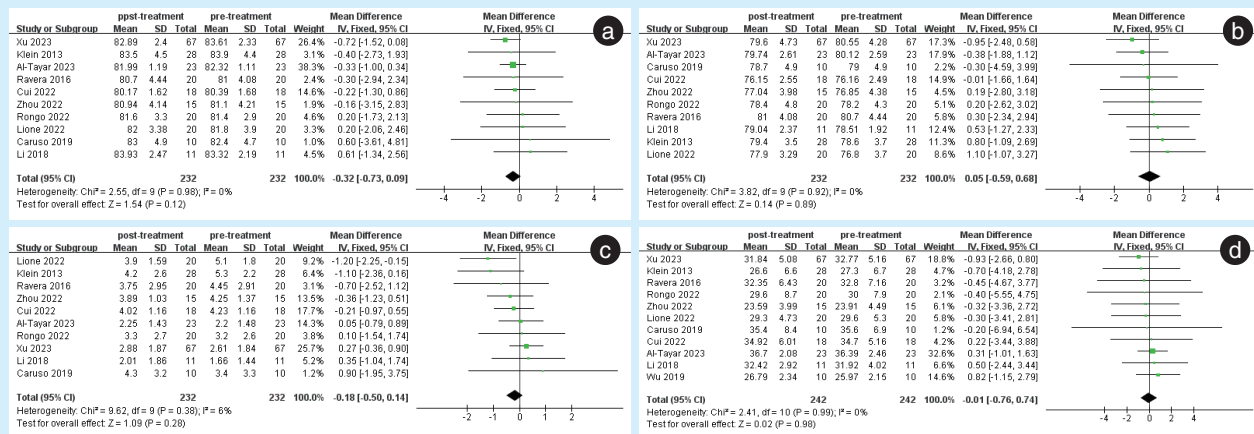
表2 纳入文献的质量评估

Table 1 The quality assessment of the included studies

Item	Al-Tayar 2023 ^[23]	Xu 2023 ^[27]	Cui 2022 ^[24]	Lione 2022 ^[21]	Rongo 2022 ^[26]	Zhou 2022 ^[28]	Cheng 2020 ^[29]	Caruso 2019 ^[22]	Wu 2019 ^[30]	Li 2017 ^[31]	Ravera 2016 ^[16]	Yang 2015 ^[32]	Klein 2013 ^[25]
A stated aim of the study	2	2	2	2	2	0	2	2	2	2	2	2	2
Inclusion of consecutive patients	1	1	1	1	1	1	1	1	1	1	2	1	1
Prospective collection of data	2	2	2	2	2	2	2	2	2	2	2	2	2
Endpoint appropriate to the study aim	2	2	2	2	2	2	2	2	2	2	2	2	2
Unbiased evaluation of endpoints	2	1	1	2	2	2	2	2	1	1	2	2	2
Follow-up period appropriate to the major endpoint	1	1	1	1	1	1	1	1	1	1	1	1	1
Loss to follow up not exceeding 5%	2	2	2	2	2	2	2	2	2	2	2	2	2
Prospective calculation of the sample size	2	0	0	2	2	0	0	0	0	0	0	0	2
Prospective calculation of the sample size	14	11	11	14	14	10	12	12	11	11	13	12	14

232名患者治疗前后的SNA大小,由于异质性不明显($I^2 = 0\%$,且 $P = 0.98$),采用固定效应模型。合并效应量 $MD = -0.32$, $95\%CI(-0.73, 0.09)$, SNA较治疗前有所减小,但差异无统计学意义($P = 0.12$),见图2a。②SNB: (sella-nasion-supramental angle, 蝶鞍中心-鼻根点-下牙槽座点角)共有10篇研究测量了232名患者治疗前后的SNB大小,由于异质性不明显($I^2 = 0\%$,且 $P = 0.92$),采用固定效应模型。合并效应量 $MD = 0.05$, $95\%CI(-0.59, 0.68)$, SNB较治疗前稍有增大,但差异无统计学意义($P = 0.89$),见图2b。③ANB(subspinale-nasion-supramental angle, 上牙槽座点-鼻根点-下牙槽座点角):共有10篇研究测量了232名患者治疗前后的ANB大小,由于异质性不明显($I^2 = 6\%$,且 $P = 0.38$),采用固定效应模型。合并效应量 $MD = -0.18$, $95\%CI(-0.50, 0.14)$, ANB较治疗前有所减小,但差

异无统计学意义($P = 0.28$),见图2c。④下颌平面角:共有11篇研究测量了242名患者治疗前后的下颌平面角大小,由于异质性不明显($I^2 = 0\%$,且 $P = 0.99$),采用固定效应模型。合并效应量 $MD = -0.01$, $95\%CI(-0.76, 0.74)$,下颌平面角基本维持不变,差异无统计学意义($P = 0.98$),见图2d。2.2.2 上颌第一磨牙移动情况森林图 ①第一磨牙矢状向位移:共有11篇研究测量了251名患者治疗前后第一磨牙矢状向位置变化,由于异质性不明显($I^2 = 0\%$,且 $P = 0.80$),采用固定效应模型。合并效应量 $MD = -2.34$, $95\%CI(-2.83, -1.85)$,治疗后上颌第一磨牙平均向远中移动2.42 mm,与治疗前相比差异有统计学意义($P < 0.001$),见图3a。②第一磨牙垂直向移动:共有8篇研究测量了132名患者治疗前后第一磨牙垂直向位置变化,由于异质性不明显($I^2 = 0\%$,且 $P = 0.90$),采用固定



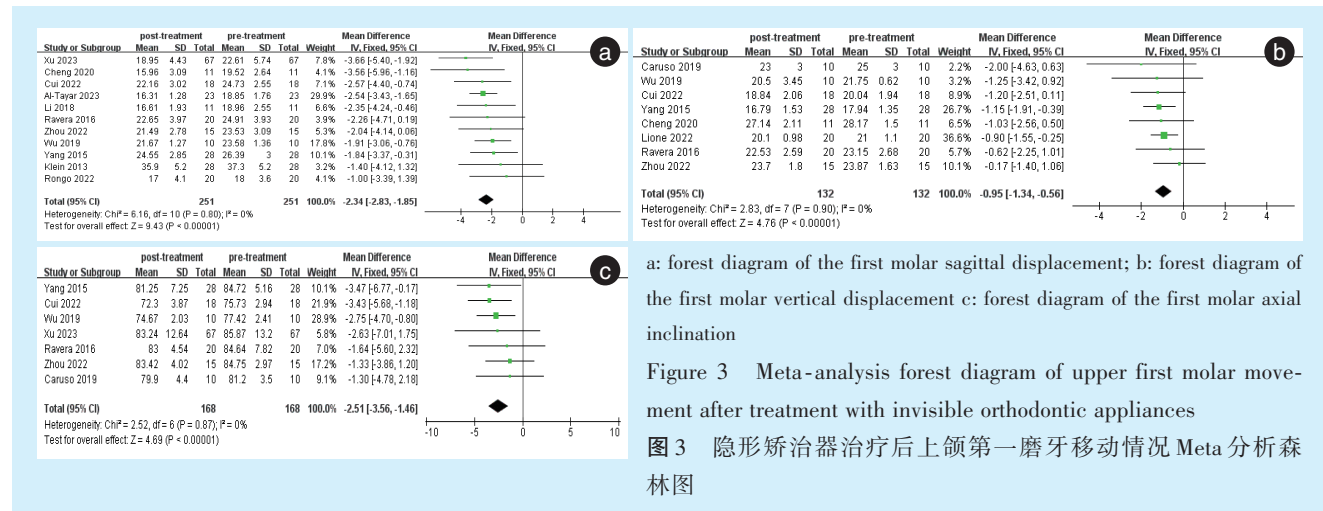
a: forest diagram of SNA; b: forest diagram of SNB; c: forest diagram of ANB; d: forest diagram of mandibular plane angle

Figure 2 Meta-analysis forest diagram of changes in the interjaw relationship after treatment with invisible orthodontic appliances

图2 隐形矫治器治疗后颌骨关系变化的Meta分析森林图

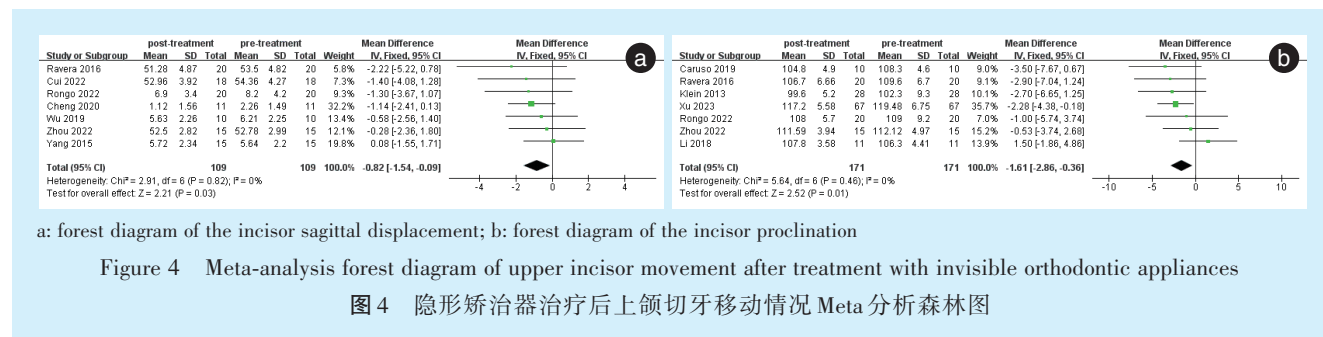
效应模型。合并效应量 $MD=-0.95$, $95\%CI$ $(-1.34, -0.56)$, 治疗后上颌第一磨牙平均被压低 0.95 mm , 与治疗前相比差异有统计学意义 ($P < 0.001$), 见图 3b。③第一磨牙轴倾度: 共有 7 篇研究测量了 168 名患者治疗前后第一磨牙轴倾度变

化, 由于异质性不明显 ($I^2 = 0\%$, 且 $P = 0.87$), 采用固定效应模型。合并效应量 $MD=-2.51$, $95\%CI$ $(-3.56, -1.46)$, 治疗后上颌第一磨牙平均向远中倾斜 2.51° , 与治疗前相比差异有统计学意义 ($P < 0.001$), 见图 3c。



2.2.3 上颌切牙移动情况森林图 ①切牙矢状向移动: 共有 7 篇文章测量了 109 名患者治疗前后切牙矢状向位置变化, 由于异质性不明显 ($I^2 = 0\%$, 且 $P = 0.82$), 采用固定效应模型。合并效应量 $MD=-0.82$, $95\%CI$ $(-1.54, -0.09)$, 治疗后切牙平均内收 0.82 mm , 与治疗前相比差异有统计学意义

($P = 0.03$), 见图 4a。②切牙唇倾度: 共有 7 篇文章测量了 171 名患者治疗前后切牙唇倾度变化, 由于异质性不明显 ($I^2 = 0\%$, 且 $P = 0.46$), 采用固定效应模型。合并效应量 $MD=-1.61$, $95\%CI$ $(-2.86, -0.36)$, 治疗后切牙平均内收 1.61° , 与治疗前相比差异有统计学意义 ($P = 0.01$), 见图 4b。



2.3 发表偏倚

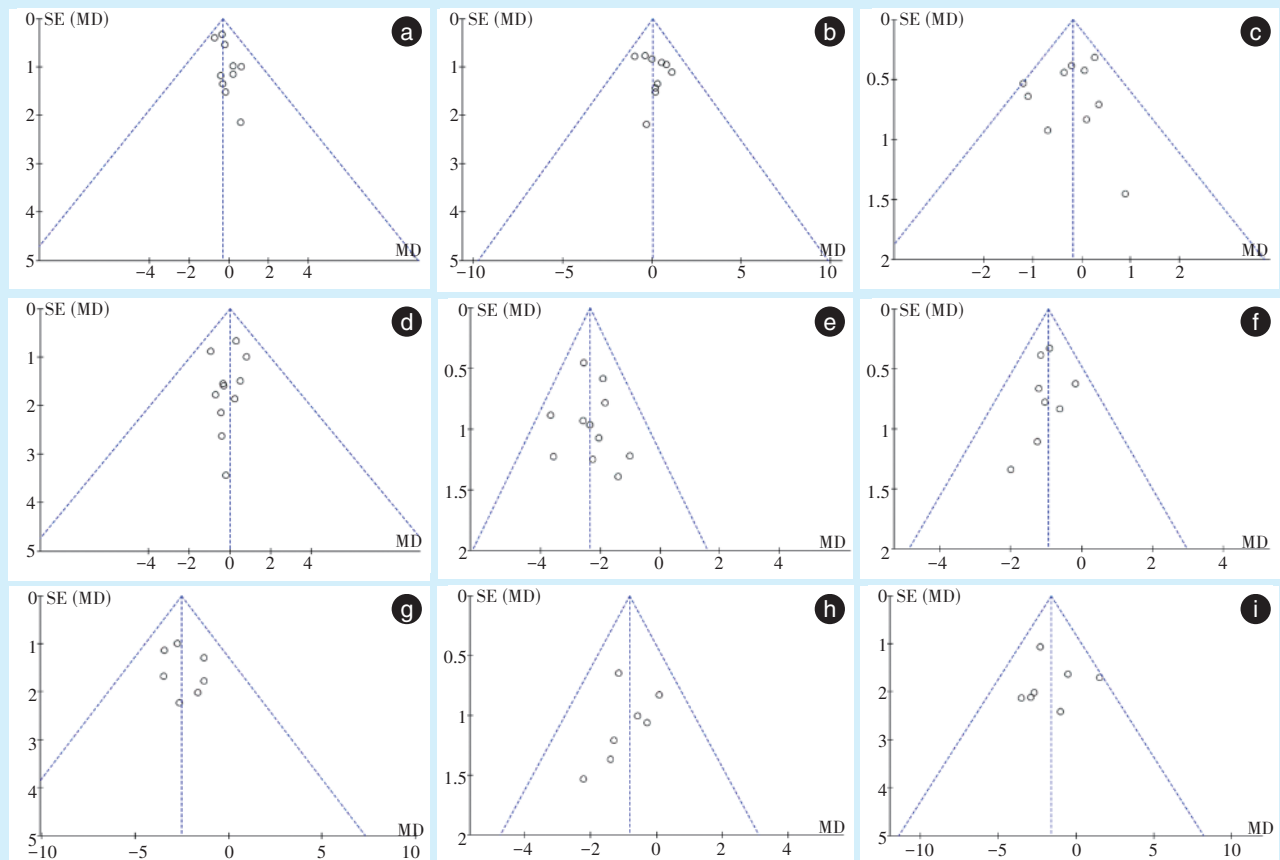
应用漏斗图及 Egger 检验进行发表偏倚评估, 见图 5 及表 3, 结果显示各项结局指标在漏斗图中分布较为对称, P 值均 > 0.05 , 可认为发表偏倚较小。

2.4 敏感性分析

对纳入研究逐一剔除后重新进行结果分析, 结果显示效应量的方向未发生明显改变, 表明 Meta 分析结果可靠、稳定。

3 讨论

本研究发现使用隐形矫治器能使磨牙平均远中移动 2.34 mm , 压低 0.95 mm , 远中倾斜 2.51° , 磨牙远移后上下颌骨矢状向相对位置关系保持稳定。这说明隐形矫治器远移磨牙后获得的间隙量有一定限度。在临床上, 对于伴有轻度牙弓狭窄的安氏 II 类错殆畸形患者可设计后牙颊向移动, 恢复后牙正常的颊、舌向倾斜度, 对缓解牙列拥挤有一定帮助。值得注意的是: 腭中缝于青春期中



a: funnel chart of publication bias for SNA; b: funnel chart of publication bias for SNB; c: funnel chart of publication bias for ANB; d: funnel chart of publication bias for mandibular plane angle; e: funnel chart of publication bias for first sagittal displacement; f: funnel chart of publication bias for first molar vertical displacement; g: funnel chart of publication bias for first molar axial inclination; h: funnel chart of publication bias for incisor sagittal displacement; i: funnel chart of publication bias for incisor proclination. SNA: sella-nasion-subspinale angle; SNB: sella-nasion-supramental angle; ANB: subspinale-nasion-supramental angle

Figure 5 Funnel chart of publication bias for each indicator

图5 各个指标发表偏倚漏斗图

表3 纳入文献发表偏倚结果汇总表

Table 3 Summary of results of publication bias in the included studies

Outcome indicator	<i>P</i> (Egger-test)
SNA	0.065
SNB	0.343
ANB	0.614
Mandibular plane angle	0.530
Sagittal displacement of the first molar	0.769
Vertical displacement of the first molar	0.739
Axial inclination of the first molar	0.493
Sagittal displacement of the incisor	0.244
Proclination of the incisor	0.950

SNA: sella-nasion-subspinale angle; SNB: sella-nasion-supramental angle; ANB: subspinale-nasion-supramental angle

本完成融合, 隐形矫治器的材料尚不能实现成年人的骨性扩弓。隐形矫治器对颌骨关系显著不调、侧貌前突的改善也有限, 其仅适用于骨性Ⅰ类, 安氏Ⅰ类或轻度Ⅱ类关系、上颌轻度拥挤^[33]、直面或微突面型的患者。对于存在明显颌骨关系不调、中重度牙列拥挤或对侧貌美学要求严格的患者应考虑配合邻面去釉、或进行拔牙矫治、甚至正颌手术的治疗方式。传统矫治器远移磨牙可能造成支点后移及下颌后旋, 而隐形矫治器对牙列的全包裹能够更好地稳定牙齿及颌骨垂直向位置^[23]。对于高角型患者的磨牙远移治疗, 隐形矫治器有其独特的优势^[21]。磨牙压低并未导致下颌平面角的减小, 这说明其主要由矫治器的“合垫效应”所导致, 隐形矫治结束后, 部分患者存在后牙开骀的现象, 可通过佩戴垂直牵引使后牙建立咬

合。若仅为后牙区咬合不紧密,可待其自然伸长。因此,磨牙的暂时压低并不会对下颌平面角度造成影响,隐形矫治器有助于控制后牙垂直向高度,维持下颌平面角的稳定。如需实现下颌的大量逆旋,需配合支抗钉进行前牙及后牙的大量压低移动。隐形矫治器进行磨牙远移具有较高的实现率,其中第二磨牙为75%,第一磨牙为69%^[34],第二磨牙远移的实现率较第一磨牙高。一篇有限元研究发现^[35],垂直矩形附件有助于减小磨牙远移过程中的轴倾度变化,使用个性化附件将前磨牙连接为整体有助于增强支抗^[36]。笔者在临床上发现,当未在第二磨牙设计附件时,远移后磨牙表现为远中倾斜,远中尖较近中尖偏向龈方,矫治器发生脱位,对于牙冠高度不足的患者,矫治器脱位情况则更加严重。

本研究还发现磨牙远移后,上颌切牙平均内收0.82 mm,舌倾1.61°,安氏Ⅱ类1分类的患者切牙需内收,而安氏Ⅱ类2分类的患者切牙需唇展,切牙内收对磨牙产生近中方向的反作用力,反之,切牙的唇向移动有助于磨牙远移,切牙的移动方向显著影响磨牙远移的实现率^[17,37]。正畸治疗纠正了安氏Ⅱ类2分类患者的内倾型深覆殆,解除了迫使关节后移位的不良因素,为下颌向前运动提供空间,因此髁突在关节窝的位置发生相应变化。研究发现安氏Ⅱ类2分类患者正畸治疗后关节前间隙明显减小,关节后间隙、关节上间隙增大,关节向前、下移位^[33]。本研究设计之初计划以安氏Ⅱ类亚类作为亚组分析的分类依据,但检索得到的文献部分未按亚类情况对患者进行分组统计分析,部分仅纳入了安氏Ⅱ类1分类的患者,因此,尚无法进行相关亚组分析,计算得出的切牙位置变化的合并统计量具有一定局限性。对于安氏Ⅱ类2分类患者,Chen等^[38]发现隐形矫治器能够显著减少切牙牙根吸收及骨开窗的发生率,牙根吸收量平均为 $(23.68 \pm 4.82) \text{ mm}^3$ 。当未设计增强支抗手段时,第二磨牙2 mm的远中移动造成前牙1.41°~2.01°的唇倾^[39],这对于安氏Ⅱ类2分类患者的治疗有利。

在使用隐形矫治器进行上颌磨牙远中移动的方案设计时,应依据磨牙计划远移量以及前牙内收量的大小决定采取何种增强支抗的方式。目前常见方式包括:颌内支抗,即以上颌其余牙齿作为支抗,序列远中移动,减少同时移动的牙齿数量及步距;颌间支抗:以下颌牙列为支抗,于下颌磨牙

颊侧面与上颌尖牙矫治器精密切割间佩戴皮筋^[40];种植体支抗:于上颌颊侧或腭侧植入支抗钉,采用弹性或刚性材料连接于上颌牙齿或矫治器。目前,对于支抗效果已经达成的共识为:种植体支抗效果最优^[41-43],其次为颌间支抗,最后为颌内支抗。根据笔者的临床经验,颌内支抗适用于1 mm以内的磨牙远移,而实现1~3 mm的远移量有必要配合Ⅱ类牵引,当移动量>3 mm时,种植体支抗为更有效的手段^[44]。值得注意的是,颌内支抗只能尽量减少前牙的唇向移动,无法实现全牙列的远中移动。程鑫焱^[29]先后将支抗钉植入于第一磨牙近中及远中颊侧牙槽骨,使用刚性连接结构分别固定于第二前磨牙颊面及第一磨牙颊面,尽可能地减少了牙齿的往复移动并提高了远移效率,其实现的磨牙远移量大于使用Ⅱ类牵引。尽管支抗钉作为“绝对支抗”,能够保障长距离的磨牙移动,但在临床实践中支抗钉植入后的稳定性、是否会干扰牙根移动,以及支抗钉两侧牵引力的垂直向分力是否存在明显的大小差异而造成咬合平面的偏斜,这些都是需要充分考量的问题^[45]。

本研究仍存在一定局限性,①本文纳入研究的测量资料包括CBCT及头颅定位侧位片,对于后者,患者头颅两侧结构不完全对称及放大倍率的差异会造成头颅侧位片总体清晰度的降低,进而影响定点分析的准确性。②测量磨牙移动时选用了不同的水平参考面(SN平面、FH平面、ANS-PNS平面),对于高角型患者,其咬合平面与水平面间夹角大,此时测量的磨牙远移量较真实值偏小,磨牙垂直向移动量较真实值偏大。③大部分研究并未对附件使用情况、矫治器佩戴方式、Ⅱ类牵引力值等做详细描述,这些因素均会对疗效造成一定影响。对于同类型随机对照试验的设计,笔者认为应对支抗及附件设计、牵引力大小、佩戴时间长短进行明确描述,并分别统计不同性别、精调前后的磨牙移动情况。

【Author contributions】 Kang FJ designed the study, collected and analyzed the data, wrote the article. Li XP, Zhang XY, Shi XN, Chang LGD collected and analyzed the data, revised the article. Zhu XC designed the study, guided and critically reviewed the article structures. All authors read and approved the final manuscript as submitted.

参考文献

- [1] Chen H, Liu L, Li Y, et al. Comparison of cytokine level changes in gingival crevicular fluid between the aligner and pendulum appliance during early molar distalization: a single-center, prospec-

- tive, observational study [J]. *J Orol Orthop*, 2023, 84(4): 243-251. doi: 10.1007/s00056-021-00359-2.
- [2] Patel MP, Henriques JF, Freitas KM, et al. Cephalometric effects of the Jones Jig appliance followed by fixed appliances in Class II malocclusion treatment [J]. *Dental Press J Orthod*, 2014, 19(3): 44-51. doi: 10.1590/2176-9451.19.3.044-051.oar.
 - [3] Vilanova L, Henriques JFC, Patel MP, et al. Class II malocclusion treatment changes with the Jones jig, Distal jet and First Class appliances [J]. *J Appl Oral Sci*, 2020, 28: e20190364. doi: 10.1590/1678-7757-2019-0364.
 - [4] Sa'ad NL, Park CO, Bayome M, et al. Skeletal and dental effects of molar distalization using a modified palatal anchorage plate in adolescents [J]. *Angle Orthod*, 2015, 85(4): 657-664. doi: 10.2319/060114-392.1.
 - [5] Acar AG, Gürsoy S, Dinçer M. Molar distalization with a pendulum appliance K-loop combination [J]. *Eur J Orthod*, 2010, 32(4): 459-465. doi: 10.1093/ejo/cjp136.
 - [6] Schütze SF, Gedrange T, Zellmann MR, et al. Effects of unilateral molar distalization with a modified pendulum appliance [J]. *Am J Orthod Dentofac Orthop*, 2007, 131(5): 600-608. doi: 10.1016/j.ajodo.2005.09.031.
 - [7] Akin E, Gurton AU, Sagdic D. Effects of a segmented removable appliance in molar distalization [J]. *Eur J Orthod*, 2006, 28(1): 65-73. doi: 10.1093/ejo/cji078.
 - [8] Wang J, Tsolaki A, Voudouris JC, et al. Three-dimensional force characterizations in maxillary molar distalization: a finite element study [J]. *Appl Sci*, 2023, 13(12): 7195. doi: 10.3390/app13127195.
 - [9] Flores-Mir C. Limited evidence on treatments for distalizing upper first molars in children and adolescents [J]. *Evid Based Dent*, 2014, 15(1): 23-24. doi: 10.1038/sj.ebd.6400988.
 - [10] Mheissen S, Khan H, Aldandan M. Limited evidence on differences between fixed appliances and clear aligners regarding pain level [J]. *Evid Based Dent*, 2020, 21(4): 144-145. doi: 10.1038/s41432-020-0140-4.
 - [11] Oikonomou E, Fors P, Tagkli A, et al. Impact of aligners and fixed appliances on oral health during orthodontic treatment: a systematic review and meta-analysis [J]. *Oral Health Prev Dent*, 2021, 19(1): 659-672. doi: 10.3290/j.ohpd.b2403661.
 - [12] Flores-Mir C. Clear aligner therapy might provide a better oral health environment for orthodontic treatment among patients at increased periodontal risk [J]. *J Evid Based Dent Pract*, 2019, 19(2): 198-199. doi: 10.1016/j.jebdp.2019.05.006.
 - [13] Zheng M, Liu R, Ni Z, et al. Efficiency, effectiveness and treatment stability of clear aligners: a systematic review and meta-analysis [J]. *Orthod Craniofac Res*, 2017, 20(3): 127-133. doi: 10.1111/ocr.12177.
 - [14] Ali Baeshen H, El-Bialy T, Alshehri A, et al. The effect of clear aligners on speech: a systematic review [J]. *Eur J Orthod*, 2023, 45(1): 11-19. doi: 10.1093/ejo/cjac018.
 - [15] Simon M, Keilig L, Schwarze J, et al. Treatment outcome and efficacy of an aligner technique: regarding incisor torque, premolar derotation and molar distalization [J]. *BMC Oral Health*, 2014, 14: 68. doi: 10.1186/1472-6831-14-68.
 - [16] Ravera S, Castroflorio T, Garino F, et al. Maxillary molar distalization with aligners in adult patients: a multicenter retrospective study [J]. *Prog Orthod*, 2016, 17: 12. doi: 10.1186/s40510-016-0126-0.
 - [17] Li L, Guo R, Zhang L, et al. Maxillary molar distalization with a 2-week clear aligner protocol in patients with Class II malocclusion: a retrospective study [J]. *Am J Orthod Dentofac Orthop*, 2023, 164(1): 123-130. doi: 10.1016/j.ajodo.2022.11.016.
 - [18] Saif BS, Pan F, Mou Q, et al. Efficiency evaluation of maxillary molar distalization using Invisalign based on palatal rugae registration [J]. *Am J Orthod Dentofac Orthop*, 2022, 161(4): e372-e379. doi: 10.1016/j.ajodo.2021.11.012.
 - [19] Huh J, Liu J, Yu JH, et al. Three-dimensional evaluation of a virtual setup considering the roots and alveolar bone in molar distalization cases [J]. *Sci Rep*, 2023, 13(1): 14955. doi: 10.1038/s41598-023-41480-z.
 - [20] Chen CL, Chen CH, Pan CY, et al. Cone beam computed tomographic analysis of the spatial limitation during mandibular arch distalization [J]. *BMC Med Imaging*, 2020, 20(1): 39. doi: 10.1186/s12880-020-00441-y.
 - [21] Lione R, Balboni A, di Fazio V, et al. Effects of pendulum appliance versus clear aligners in the vertical dimension during Class II malocclusion treatment: a randomized prospective clinical trial [J]. *BMC Oral Health*, 2022, 22(1): 441. doi: 10.1186/s12903-022-02483-w.
 - [22] Caruso S, Nota A, Ehsani S, et al. Impact of molar teeth distalization with clear aligners on occlusal vertical dimension: a retrospective study [J]. *BMC Oral Health*, 2019, 19(1): 182. doi: 10.1186/s12903-019-0880-8.
 - [23] Al-Tayar B, Al-Somairi MAA, Alshoaibi LH, et al. Impact of molar teeth distalization by clear aligners on temporomandibular joint: a three-dimensional study [J]. *Prog Orthod*, 2023, 24(1): 25. doi: 10.1186/s40510-023-00474-3.
 - [24] Cui JY, Ting L, Cao YX, et al. Morphology changes of maxillary molar distalization by clear aligner therapy [J]. *Int J Morphol*, 2022, 40(4): 920-926. doi: 10.4067/s0717-95022022000400920.
 - [25] Klein BM. A cephalometric study of adult mild Class II non-extraction treatment with the Invisalign system [D]. Missouri: Saint Louis University, 2013.
 - [26] Rongo R, Dianišková S, Spiezia A, et al. Class II malocclusion in adult patients: what are the effects of the intermaxillary elastics with clear aligners? A retrospective single center one-group longitudinal study [J]. *J Clin Med*, 2022, 11(24): 7333. doi: 10.3390/jcm11247333.
 - [27] 许颖华. 无托槽隐形矫治技术远中移动上颌磨牙对骨性 I 类及 II 类错殆畸形的疗效 [J]. *贵州医科大学学报*, 2023, 48(7): 848-851, 857. doi: 10.19367/j.cnki.2096-8388.2023.07.017.
Xu YH. Efficacy of invisible bracketless technique on distally moving maxillary molars over class I and II malocclusion deformity [J]. *J Guizhou Med Univ*, 2023, 48(7): 848-851, 857. doi: 10.19367/j.cnki.2096-8388.2023.07.017.

- [28] 周思颖, 张婧, 彭早霞, 等. 应用CBCT评估隐形矫治技术远移上颌磨牙的临床疗效 [J]. 中国美容医学, 2022, 31(8): 90-94. doi: 10.15909/j.cnki.cn61-1347/r.005220.
- Zhou SY, Zhang J, Peng ZX, et al. Researches on the effects of upper molars distalization with clear aligner treatment by cone-beam computed tomography [J]. Chin J Aesthetic Med, 2022, 31(8): 90-94. doi: 10.15909/j.cnki.cn61-1347/r.005220.
- [29] 程鑫赓. 微种植钉刚性连接辅助无托槽隐形矫治器远移上颌磨牙效果的CBCT评价 [D]. 南昌: 南昌大学, 2020.
- Cheng XY. CBCT evaluation of the anchorage effect of rigid connection of mini-implant assisted clear aligner appliance for patients with maxillary molar distalization [D]. Nanchang: Nanchang University, 2020.
- [30] 吴迪, 向美玲, 唐林, 等. 无托槽隐形矫治器推磨牙向远中的阶段性研究 [J]. 口腔医学, 2019, 39(11): 987-992. doi: 10.13591/j.cnki.kqyx.2019.11.006.
- Wu D, Xiang ML, Tang L, et al. A phased study on molars distalization with bracketless invisible appliance [J]. Stomatology, 2019, 39(11): 987-992. doi: 10.13591/j.cnki.kqyx.2019.11.006.
- [31] 李志芳, 王伟财, 麦理想. 无托槽隐形矫治技术远移磨牙治疗上前牙轻、中度拥挤的效果 [J]. 口腔疾病防治, 2018, 26(5): 314-319. doi: 10.12016/j.issn.2096-1456.2018.05.007.
- Li ZF, Wang WC, Mai LX. The clinical effects of Invisalign-aided molar distalization in the treatment of mild or moderate crowding in anterior teeth [J]. J Prev Treat Stomatol Dis, 2018, 26(5): 314-319. doi: 10.12016/j.issn.2096-1456.2018.05.007.
- [32] 杨偲偲. 隐形矫治技术远中移动上颌磨牙疗效的CBCT评价 [D]. 上海: 上海交通大学, 2015.
- Yang SS. Efficacy of invisalign on upper molar distalization via CBCT evaluation [D]. Shanghai: Shanghai Jiao Tong University, 2015.
- [33] Lin SY, Hung MC, Lu LH, et al. Treatment of class II malocclusion with Invisalign®: a pilot study using digital model-integrated maxillofacial cone beam computed tomography [J]. J Dent Sci, 2023, 18(1): 353-366. doi: 10.1016/j.jds.2022.08.027.
- [34] D'Antò V, Valletta R, Ferretti R, et al. Predictability of maxillary molar distalization and derotation with clear aligners: a prospective study [J]. Int J Environ Res Public Health, 2023, 20(4): 2941. doi: 10.3390/ijerph20042941.
- [35] Ayidağa C, Kamiloglu B. Effects of variable composite attachment shapes in controlling upper molar distalization with aligners: a nonlinear finite element study [J]. J Healthc Eng, 2021, 2021: 5557483. doi: 10.1155/2021/5557483.
- [36] Jia L, Wang C, Li L, et al. The effects of lingual buttons, precision cuts, and patient-specific attachments during maxillary molar distalization with clear aligners: comparison of finite element analysis [J]. Am J Orthod Dentofac Orthop, 2023, 163(1): e1-e12. doi: 10.1016/j.ajodo.2022.10.010.
- [37] Roberto S, Paoloni V, Pavoni C, et al. Anchorage loss evaluation during maxillary molars distalization performed by clear aligners: a retrospective study on 3D digital casts [J]. Appl Sci, 2023, 13(6): 3646. doi: 10.3390/app13063646.
- [38] Chen H, Liu L, Han M, et al. Changes of maxillary central incisor and alveolar bone in Class II Division 2 nonextraction treatment with a fixed appliance or clear aligner: a pilot cone-beam computed tomography study [J]. Am J Orthod Dentofac Orthop, 2023, 163(4): 509-519. doi: 10.1016/j.ajodo.2022.02.015.
- [39] Mao B, Tian Y, Xiao Y, et al. The effect of maxillary molar distalization with clear aligner: a 4D finite-element study with staging simulation [J]. Prog Orthod, 2023, 24(1): 16. doi: 10.1186/s40510-023-00468-1.
- [40] Liu X, Wang W, Gao J, et al. Actual contribution ratio of maxillary and mandibular molars for total molar relationship correction during maxillary molar sequential distalization using clear aligners with Class II elastics: a finite element analysis [J]. Am J Orthod Dentofac Orthop, 2023, 164(4): e106-e120. doi: 10.1016/j.ajodo.2023.07.007.
- [41] Castroflorio T, Parrini S, Rossini G, et al. Upper first molar and second premolar distalization with clear aligner and interradicular skeletal anchorage: a finite element study [J]. Appl Sci, 2023, 13(17): 9695. doi: 10.3390/app13179695.
- [42] Cui J, Yao C, Zhang Z, et al. Maxillary molar distalization treated with clear aligners combined with mini-implants and angel button using different traction force: a finite element study [J]. Comput Methods Biomech Biomed Engin, 2023; 1-10. doi: 10.1080/10255842.2023.2183735.
- [43] Liu X, Wu J, Cheng Y, et al. Effective contribution ratio of the molar during sequential distalization using clear aligners and micro-implant anchorage: a finite element study [J]. Prog Orthod, 2023, 24(1): 35. doi: 10.1186/s40510-023-00485-0.
- [44] Raghis TR, Alsulaiman TMA, Mahmoud G, et al. Efficiency of maxillary total arch distalization using temporary anchorage devices (TADs) for treatment of Class II-malocclusions: a systematic review and meta-analysis [J]. Int Orthod, 2022, 20(3): 100666. doi: 10.1016/j.ortho.2022.100666.
- [45] Özsoy B, Güldüren K, Kamiloglu B. Effect of low-level laser therapy on orthodontic tooth movement during miniscrew-supported maxillary molar distalization in humans: a single-blind, randomized controlled clinical trial [J]. Lasers Med Sci, 2023, 38(1): 76. doi: 10.1007/s10103-023-03736-y.

(编辑 罗燕鸿, 张晨)



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