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· 基础研究 ·

## 2种消毒剂对牙周超声洁牙机独立水路消毒效果的比较

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**【摘要】** 目的 比较体积分数3%过氧化氢溶液和500 mg/L含氯消毒液分别用于牙周超声洁牙机独立水路的消毒效果,为口腔科临床水路消毒管理工作提供参考。方法 将牙周科18台超声洁牙机随机分成3组,1个对照组和2个实验组,每组6台。对照组更换无菌水源和供水管,对机器及手柄连接线内不可更换的水路管道不做处理;实验组更换无菌水源和供水管,对不可更换的水路管道采用消毒剂消毒处理。实验1组采用3%过氧化氢溶液消毒,实验2组采用500 mg/L的含氯消毒液消毒。3组均在当天消毒前、消毒后即刻、消毒后1~10 d每天开诊前在洁牙机工作端出水口取水检测,进行水样细菌培养及菌落计数,比较组内及组间消毒前后菌落数,水中菌落数不超过100 CFU/mL为合格。消毒后在每组菌落数首次出现超标时进行一次细菌种类质谱鉴定分析。在消毒后第10天时扫描电镜观察3组水路管道内壁生物膜情况。**结果** 消毒前,3组细菌菌落计数均不合格,差异无统计学意义( $F = 2.549, P = 0.111$ )。消毒后,各时间点对照组洁牙机出水口水样细菌菌落数均超标,培养出瓜类鞘氨醇单胞菌、哈特草螺菌、皮氏罗尔斯通氏菌3种细菌。实验1组消毒后第1、2天的水样菌落数达标,与对照组相比,差异有统计学意义( $P < 0.05$ ),消毒后第3天起菌落数超标,同时培养出鞘氨醇单胞菌、哈特草螺菌、皮氏罗尔斯通氏菌3种细菌。实验2组消毒后第1~6天菌落数达标,与对照组比较,差异有统计学意义( $P < 0.05$ ),消毒后第7天起每日菌落数超标,同时培养出哈特草螺菌和皮氏罗尔斯通氏菌2种细菌。实验2组消毒后的10 d平均菌落数少于实验1组( $P < 0.001$ )。电镜下见2个实验组生物膜厚度明显低于对照组。**结论** 牙周超声洁牙机独立水路存在污染;3%过氧化氢溶液和500 mg/L含氯消毒液两种消毒剂对洁牙机内水路均有消毒作用,500 mg/L含氯消毒液消毒效果优于3%过氧化氢溶液;采用3%过氧化氢溶液消毒牙周超声洁牙机独立水路建议隔日消毒1次,采用500 mg/L含氯消毒液则建议每周消毒1次。

**【关键词】** 超声波洁牙机; 独立水路; 内置水管; 菌落计数; 消毒管理; 3%过氧化氢溶液; 含氯消毒液; 消毒时机; 细菌质谱鉴定; 生物膜

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**Comparison of the effect of two disinfectants on the independent waterway disinfection of a periodontal ultrasonic scaler** HOU Yarong<sup>1,2</sup>, NI Jia<sup>2</sup>, ZHOU Qiaoyi<sup>2</sup>, GAO Yulin<sup>1</sup>, ZHANG Xiaoyan<sup>2</sup>, CHEN Xiaochuan<sup>2</sup>. 1. School of Nursing, Southern Medical University, Guangzhou 510515, China; 2. Stomatological Hospital, School of Stomatology, Southern Medical University, Guangzhou 510280, China

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**【Abstract】 Objective** To compare the disinfection effect of 3% (v/v) hydrogen peroxide and 500 mg/L chlorine-containing disinfectants in the independent waterway of a periodontal ultrasonic scaler to provide a reference for clinical waterway disinfection management in stomatology departments. **Methods** The 18 ultrasonic scalers were randomly divided into 3 groups of 6 units: the control group, experimental group 1 (3% hydrogen peroxide disinfectant group), and ex-



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perimental group 2 (500 mg/L chlorine-containing disinfectant group). The replaceable parts of the independent waterway pipes of the 3 groups of ultrasonic scalers were replaced, and the water supply was supplied with sterile distilled water (DW). In the control group, special treatment was not applied to the nonreplaceable pipe part. In experimental group 1, the 3% hydrogen peroxide was used to disinfect nonreplaceable pipelines. In experimental group 2, the nonreplaceable part was disinfected with the 500 mg/L chlorine-containing disinfectant. The water sample was taken from the outlet of the scaler working part in the three groups for monitoring before disinfection, immediately after disinfection and 10 consecutive days after disinfection. Bacteria in the water samples were cultured for the colony counts. Then, the bacterial culture data were compared between groups. The qualified criterion of the water sample was that the number of bacterial colonies was less than or equal to 100 CFU/mL. After disinfection, a bacterial species mass spectrometry identification analysis was carried out when the number of bacterial colonies in each group exceeded the standard for the first time. Biofilms from the inner wall of the tube in the three groups were observed under an electron microscope on the 10th day after disinfection. **Results** There were no significant differences between the three groups before disinfection ( $F = 2.549, P = 0.111$ ). The number of bacterial colonies in the spout of 6 scalers in the control group all exceeded the standard, and three kinds of bacteria were cultured: *Sphingomonas melonis*, *Herbaspirillum huttiense*, and *Ralstonia pickettii*. Compared with those in the control group, the number of bacterial colonies in experimental group 1 decreased significantly for 1-2 days after disinfection ( $P < 0.05$ ) and reached the standard. On the 3rd day after disinfection, the number of bacterial colonies of group 1 increased rapidly and exceeded the standard, and three kinds of bacteria were cultured: *Sphingomonas*, *Herbaspirillum huttiense*, and *Ralstonia pickettii*. For experimental group 2, the number of bacterial colonies decreased significantly compared to the control group on Days 1 to 6 after disinfection, but the number of bacterial colonies increased slightly from the 7th day after disinfection and exceeded the standard. Two kinds of bacteria were cultured: *Herbaspirillum huttiense* and *Ralstonia pickettii*. The average number of bacterial colonies 10-day after disinfection in experimental group 2 was lower than that in experimental group 1 ( $P < 0.001$ ). Under an electron microscope, the biofilm thickness of the two experimental groups was significantly lower than that of the control group. **Conclusion** There is water pollution in the independent waterway of a periodontal ultrasound scaler. Three percent hydrogen peroxide and 500 mg/L chlorine disinfectant both have effective disinfection effects on the outlet water of scalers, and the effect of 500 mg/L chlorine disinfectant is better than that of 3% hydrogen peroxide. The use of 3% hydrogen peroxide to disinfect periodontal ultrasound scaler-independent waterways is recommended for disinfection every other day, and disinfection once a week is recommended for the use of 500 mg/L chlorine disinfectant.

**【Key words】** ultrasonic scaler; independent waterline disinfection; nonreplaceable pipe; colony counting; disinfection management; 3% hydrogen peroxide solution; chlorine - containing disinfectants; disinfection timing; bacterial species mass spectrometry identification; biofilm

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综合治疗台和独立的超声波洁牙机是口腔科比较常用的设备,两者有不同的水路系统,由于其存在特殊的医院感染隐患,口腔治疗设施的水路消毒问题日益受到国内外学者的关注<sup>[1-4]</sup>。近年来众多学者对牙科综合治疗台水路污染情况、消毒方法、消毒剂的选择、应对措施、污染微生物种类等不同方面进行研究<sup>[1, 3, 5-6]</sup>,但对独立的超声洁牙机水路污染情况的研究较少。牙周超声洁牙机水路系统由储水罐/水源、供水管、主机内置水管、手柄连接线/手柄内置水管、治疗工作头组成。其

中储水罐/水源、供水管可以进行更换,治疗工作头采用高温高压灭菌一人一换,而超声洁牙机和手柄连接线/手柄内置水管非损坏维修不更换。因此,牙周超声洁牙机独立水路同样可能存在水路污染情况。3%过氧化氢溶液和500 mg/L的含氯消毒液在口腔综合治疗台水路管道中有较好的杀菌效果<sup>[6]</sup>,但未有用于超声洁牙机水路管道的消毒研究。因此,本研究拟对比3%过氧化氢溶液和500 mg/L的含氯消毒液对牙周超声洁牙机水路的消毒效果和消毒时机,为临床护理人员进行超声波洁牙机

独立水路的精准感控提供依据。

## 1 材料和方法

### 1.1 实验材料及设备

某口腔专科医院牙周超声洁牙机, XO 超声治疗仪二代机(深圳市天健恒达科技有限公司中国区总代, 丹麦)6台、啄木鸟 PT5 超声牙周治疗仪(桂林市啄木鸟医疗器械有限公司, 中国)6台、赛特力 P5XS 超声治疗仪(爱龙集团, 法国)6台, 本次实验选用3种品牌的超声洁牙机, 3种机型虽工作原理不同, 但水路管道的构造基本相似, 水路长度相近, 根据机器说明书, 水路管道材料均能耐受体积分数3%过氧化氢溶液和500 mg/L 含氯消毒液进行消毒。3%过氧化氢消毒溶液(广东恒建制药有限公司, 中国), 500 mg/L 含氯消毒液(健之素, 成分三氯异氢尿酸, 中国)。对牙周超声洁牙机独立水路的不可更换部分: 主机内置管道、手柄连接线内置管道进行消毒研究; 其余可以更换部分按常规定期更换。MS1000 质谱仪(MS1000, 安图, 中国), 扫描电镜(S4800, 日立, 日本)。

### 1.2 消毒及水样采集

18台超声洁牙机随机分成3组, 每组6台, 每组均含有奥丹二代机、啄木鸟 PT5、赛特力 P5XS 3种机型各2台, 分别为对照组、实验1组(3%过氧化氢溶液消毒组)、实验2组(500 mg/L 含氯消毒液组)。在上午工作结束后, 对3组超声洁牙机独立水路管道的可更换部分: 无菌蒸馏水水源、无菌供水管均进行更换。对照组对不可更换的管道: 主机内置水管、手柄连接线内置水管不做特殊处理; 实验1组对不可更换的管道采用3%过氧化氢溶液冲洗3 min, 在管道充满3%过氧化氢溶液的情况下, 静置30 min后, 用无菌蒸馏水冲洗管道3 min, 完成水路消毒; 实验2组对不可更换部分采用500 mg/L 含氯消毒液冲洗3 min, 在水路充满含氯消毒溶液的情况下, 静置30 min后, 用无菌蒸馏水冲洗管道3 min, 用含氯测试纸比色法对管道冲洗后水中含氯量进行检测, 确保残余氯小于0.02 mg/L后完成消毒。保证每台机器每天至少工作6 h, 并在每天工作结束后将水路内的水排净过夜。固定2名护士在无菌操作下, 分别在更换/消毒管道前、更换/消毒管道后对3组机器的工作端出水口取水; 第二天起每天开诊前, 对3组机器开机冲洗3 min, 在工作端出水口取水10 mL, 进行检测, 连续10 d, 记录出水口水样中的细菌菌落数及细菌种类情况。消

毒、取样、更换水源及供水管工作均由经过同质化培训的2名护士完成。在实验第6~8天, 参与实验的18台机器使用的一次性桶装无菌蒸馏水陆续用完, 与供水管一起遵循无菌操作原则进行更换。

### 1.3 细菌培养及检测

所取水样参照《生活饮用水标准检验方法 第12部分: 微生物指标》GB 5750.12-2023的检测方法进行检测。在室温环境下, 取1 mL 采集水样加入无菌培养皿, 倾注营养琼脂, 混匀, 待琼脂凝固后放于35℃温箱中培养48 h, 行菌落计数。

所取水样送检进行细菌培养, 从琼脂里面的菌落中根据形态、变异度的不同挑出纯菌落分至哥伦比亚血培养基培养, 肉眼观察是否为纯菌落, 将纯菌落挑出涂抹至质谱仪靶板上, 加入基质液, 待干燥后放入MS1000 质谱仪中进行细菌种类鉴定, 进一步观察水样中所含细菌的种类。在消毒后第10天, 对3组超声洁牙机内置管道的软水管部分用无菌剪刀剪取约0.5 cm长度的管道, 纵向剖开, 用0.25%戊二醛液固定, 置于扫描电镜下进行观察, 比较3组生物膜的厚度及脱落情况。

### 1.4 水样合格判定标准

参照《生活饮用水卫生标准》GB 5749-2022 以及《口腔综合治疗台水路消毒技术规范》<sup>[7]</sup>中的规定, 口腔治疗用水菌落数不超过100 CFU/mL, 本研究以此作为水质是否合格的判定标准。

### 1.5 统计学处理

测量各组消毒前及消毒后10 d产生的菌落数, 其中消毒前数据记为d01, 消毒后即刻测量记为d02, 之后数据依次记为d1~d10, 每天1次共11次测量。实验设计为两因素重复测量设计, 且由于部分数据不符合正态性, 故本次统计分析采用广义线性混合模型进行分析, 统计描述采用均数±标准差表述。

## 2 结果

### 2.1 各组各测量时点菌落数分布情况

消毒前3组数据(d01)符合正态性及方差齐性, 方差分析结果显示组间差异无统计学意义( $F = 2.549, P = 0.111$ ), 菌落数均不达标。3组各时点菌落数分布详见表1。在消毒后第3天时实验1组出现了菌落数激增(123.500 CFU/mL), 说明3%过氧化氢溶液短期内能够有效抑制菌落生长; 实验2组菌落数则在消毒后第7天时超标(144.167 CFU/mL), 说明500 mg/L 含氯消毒液具有

对菌落生长的长效抑制作用。实验2组消毒后的10 d平均菌落数少于实验1组( $P < 0.01$ )。不同组别间菌落数差异具有统计学意义( $F = 623.309$ ,  $P < 0.001$ ), 组别与测量时点存在交互效应( $F = 42.005$ ,  $P < 0.001$ )。

表1 3组各测量时点菌落数

Table 1 The number of bacterial colonies at each measurement time point in the three groups  $\bar{x} \pm s$ , CFU/mL

Time	Control group	Experimental group 1	Experimental group 2
d01	359.833 ± 72.430	350.833 ± 48.840	289.833 ± 51.105
d02	326.167 ± 52.670	0.667 ± 1.211	0.500 ± 0.837
d1	369.333 ± 25.563	0.500 ± 0.548	2.167 ± 1.835
d2	364.333 ± 75.545	16.667 ± 8.066	1.167 ± 1.835
d3	316.167 ± 57.898	123.500 ± 43.224	0.833 ± 2.041
d4	390.167 ± 73.382	189.000 ± 18.644	2.167 ± 1.835
d5	356.333 ± 67.039	175.167 ± 50.681	14.333 ± 5.888
d6	329.333 ± 68.765	156.333 ± 42.017	73.167 ± 12.952
d7	329.833 ± 77.326	200.000 ± 37.491	144.167 ± 47.343
d8	348.500 ± 52.876	267.833 ± 44.038	177.500 ± 26.508
d9	355.333 ± 47.727	168.000 ± 62.702	161.333 ± 28.126
d10	363.000 ± 44.533	209.667 ± 17.201	180.167 ± 19.974
Mean ± SE	350.090 ± 9.227	60.386 ± 4.923	16.829 ± 1.626

Control group: no disinfection treatment. Experimental group 1: 3% hydrogen peroxide disinfectant. Experimental group 2: 500 mg/L chlorine-containing disinfectant group. There was a main effect in the group ( $F = 623.309$ ,  $P < 0.001$ ), and an interaction effect between the group and the measurement time point ( $F = 42.005$ ,  $P < 0.001$ ). d01: before disinfection. d02: immediately after disinfection. d1-d10: 10 consecutive days after disinfection

各测量时点组间菌落数两两比较结果如表2所示,消毒后即刻测量时点d02,对照组菌落数与其余两组实验组差异均存在统计学意义,实验组组间差异无统计学意义( $P = 0.753$ )。

消毒后第1天至第10天菌落数结果显示,对照组菌落数与进行干预后的两组实验组的差异均存在统计学意义,表明3%过氧化氢或500 mg/L含氯消毒液的干预均能有效抑制菌落的产生。

消毒后第1天至第8天菌落数结果显示,实验1组与实验2组间菌落数的差异均有统计学意义,除d1时点外( $MD = -1.667$ ,  $P = 0.042$ ),实验2组产生的菌落数均少于实验1组。并且在第1天至第4天阶段,菌落数差异增大,之后两实验组间的菌落数差异总体上缩小(表2)。

## 2.2 质谱鉴定细菌种类情况

对3组水样中菌落数进行监测,消毒后,当各组菌落数首次超过100 CFU/mL时则进行一次细菌

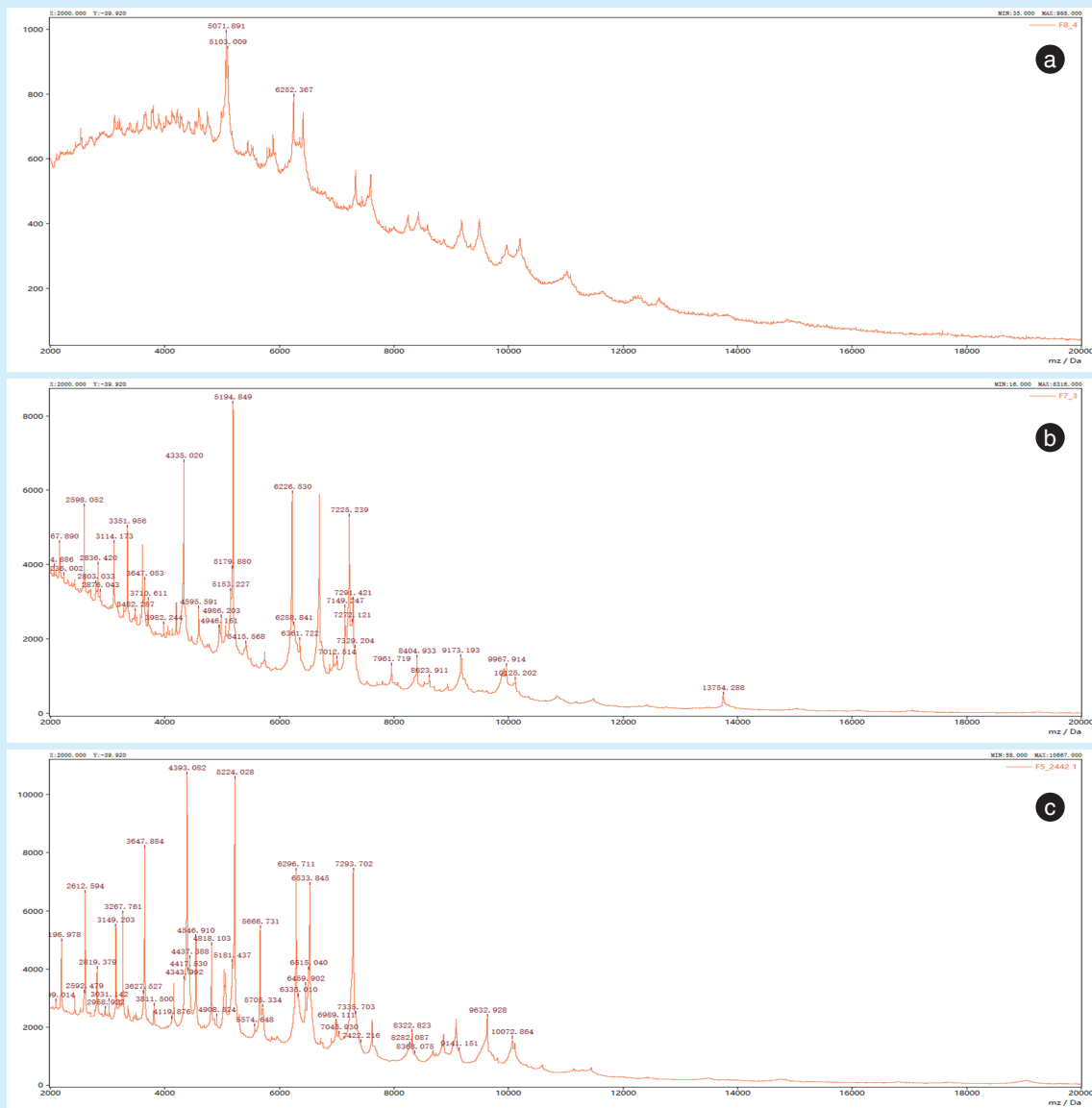
种类质谱鉴定。结果显示,对照组在更换管道后即刻取水的超标水样中培养出瓜类鞘氨醇单胞菌(评分9.277分)、哈特草螺菌(评分9.478分)、皮氏罗尔斯通氏菌(评分9.539分)3种细菌(图1);实验1组

表2 各测量时点组间菌落数两两比较结果(简单效应分析)

Table 2 Pairwise comparison results of the number of bacterial colonies between groups at different measurement time points (simple effect analysis) CFU/mL

Time	Group pairwise	MD	SE	t	p	95% CI	
						Lower	Upper
d02	1-2	325.500	28.855	11.281	<0.001	255.955	395.045
	1-3	325.667	28.854	11.287	<0.001	260.593	390.741
	2-3	0.167	0.529	0.315	0.753	-0.877	1.210
d1	1-2	368.833	32.496	11.350	<0.001	290.513	447.154
	1-3	367.167	32.502	11.297	<0.001	293.865	440.468
	2-3	-1.667	0.814	-2.047	0.042	-3.273	-0.060
d2	1-2	347.667	32.164	10.809	<0.001	270.146	425.187
	1-3	363.167	32.077	11.322	<0.001	290.825	435.508
	2-3	15.500	2.486	6.235	<0.001	10.594	20.406
d3	1-2	192.667	30.362	6.346	<0.001	132.755	252.579
	1-3	315.333	28.012	11.257	<0.001	247.820	382.847
	2-3	122.667	11.731	10.457	<0.001	96.210	149.123
d4	1-2	201.167	38.359	5.244	<0.001	125.476	276.857
	1-3	388.000	34.259	11.325	<0.001	305.430	470.570
	2-3	186.833	17.285	10.809	<0.001	147.851	225.815
d5	1-2	181.167	35.284	5.134	<0.001	111.543	250.791
	1-3	342.000	31.474	10.866	<0.001	266.142	417.858
	2-3	160.833	16.249	9.898	<0.001	124.188	197.478
d6	1-2	173.000	32.532	5.318	<0.001	99.631	246.369
	1-3	256.167	30.053	8.524	<0.001	183.734	328.599
	2-3	83.167	16.299	5.103	<0.001	51.005	115.328
d7	1-2	129.833	34.374	3.777	<0.001	52.310	207.357
	1-3	185.667	32.124	5.780	<0.001	108.242	263.091
	2-3	55.833	22.645	2.466	0.015	11.150	100.516
d8	1-2	80.667	38.953	2.071	0.040	3.804	157.530
	1-3	171.000	34.789	4.915	<0.001	87.152	254.848
	2-3	90.333	28.951	3.120	0.004	25.041	155.626
d9	1-2	187.333	34.936	5.362	<0.001	108.543	266.124
	1-3	194.000	34.690	5.592	<0.001	110.393	277.607
	2-3	6.667	21.515	0.310	0.757	-35.787	49.120
d10	1-2	153.333	37.189	4.123	<0.001	69.462	237.205
	1-3	182.833	35.978	5.082	<0.001	96.121	269.546
	2-3	29.500	25.191	1.171	0.243	-20.208	79.208

MD: represents mean difference between groups. Multiple comparisons between groups were corrected using the Sequential Sidak method. 1: control group (no disinfection treatment). 2: experimental group 1 (3% hydrogen peroxide). 3: experimental group 2 (500 mg/L chlorine-containing disinfectant). Overall, bacterial colonies produced by the chlorine-containing disinfectant group is less than the hydrogen peroxide disinfection group and control group. d02: immediately after disinfection. d1-d10: 10 consecutive days after disinfection



a: *Sphingomonas melonis*; b: *Herbaspirillum huttiense*; c: *Ralstonia pickettii*. Control group: no disinfection treatment

Figure 1 Bacterial mass spectrometry identification in the water sample of control group

图1 对照组水样细菌质谱鉴定

在第3天出现菌落数超标时进行质谱鉴定,培养出鞘氨醇单胞菌、哈特草螺菌和皮氏罗尔斯通氏菌3种细菌;而实验2组在消毒后第7天出现菌落数超标时进行质谱鉴定,培养出哈特草螺菌和皮氏罗尔斯通氏菌2种细菌。3组均未检出金黄色葡萄球菌和铜绿假单胞菌。

### 2.3 牙周超声洁牙机内置水路管道生物膜观察

为了观察、比较消毒前后超声洁牙机内置水路管道内壁附着的细菌生物膜情况,消毒后第10天时,采用扫描电镜对3组水路管道内壁进行观察,结果可见管道内壁表面均有生物膜的形成,扫描电镜下见软管表面有众多山丘样隆起的连续

的带状物,对照组水路管道内壁中附着有大量的细菌,其中包括有杆状、球状及丝状等不同形态的细菌,且有些细菌黏着成团,附着于管壁。在3%过氧化氢溶液或含氯消毒液消毒后,管道内壁菌落数明显降低,实验1组3%过氧化氢溶液消毒后的管道内壁表面有少量球菌,而实验2组含氯消毒液消毒后的管壁则附着有一定量的杆状菌。从横截面看,过氧化氢溶液和含氯消毒液消毒后的管道内的细菌生物膜厚度明显降低,密度厚薄不均。对照组生物膜厚度约为8.33  $\mu\text{m}$ ,实验1组约为1.19  $\mu\text{m}$ ,实验2组约为2.18  $\mu\text{m}$ 。从表面看,实验1组和实验2组表面有明显生物膜剥脱现象,其

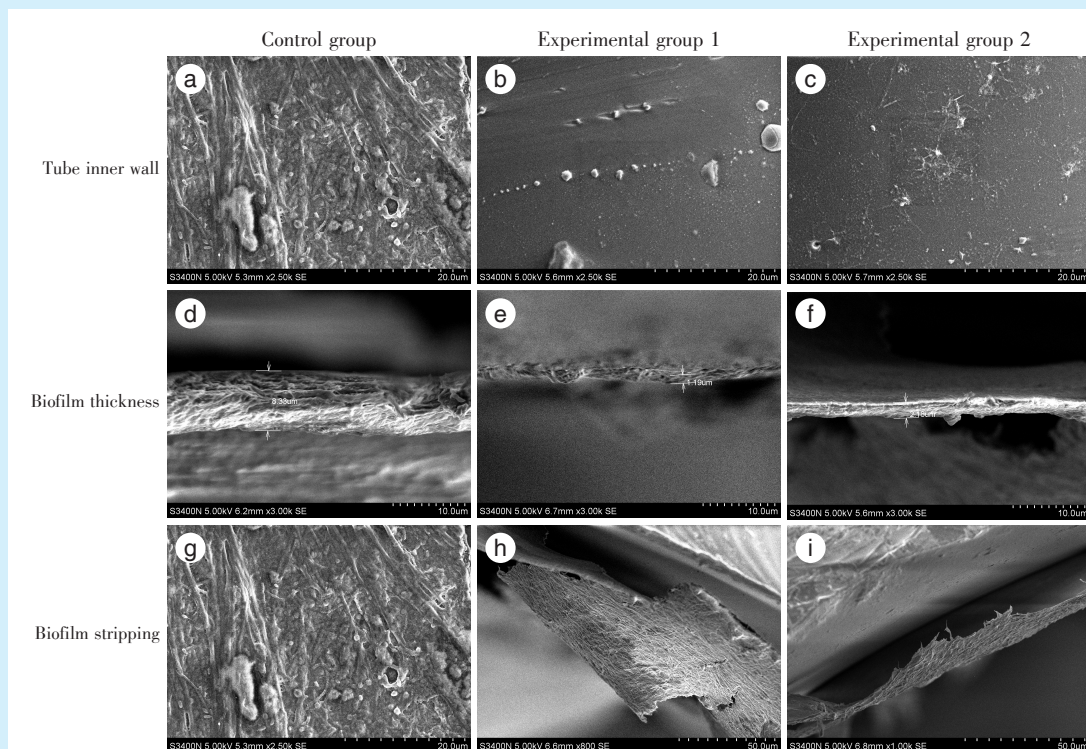
中,实验2组生物膜剥离情况优于实验1组,对照组生物膜剥离情况不明显(图2)。

### 3 讨论

#### 3.1 消毒剂对超声洁牙机水路的消毒效果

近年来,不同国家、不同地域、不同级别口腔医疗机构的牙科综合治疗台均有管道污染情况报道,发现有不同程度的水路污染<sup>[8-14]</sup>。本实验所有洁牙机工作端出水口水样中细菌菌落数在未消毒的情况下全部超标,提示独立超声洁牙机水路中存在一定程度的微生物污染,微生物主要以浮游微生物和水管内壁附着的生物膜形式存在<sup>[9,15]</sup>,本次实验测出水样中含有鞘氨醇单胞菌、皮氏罗尔斯顿菌、哈特草螺菌等多种条件致病菌。鞘氨醇单胞菌属广泛分布于环境中,只有少动鞘氨醇单胞菌和类少动鞘氨醇单胞菌具有重要的临床意

义。皮氏罗尔斯顿菌可分离自各种临床标本和引起各种感染,包括菌血症、脑膜炎、心内膜炎和骨髓炎。哈特草螺菌是革兰阴性杆菌,可能与呼吸道囊性纤维化相关。微生物在独立超声洁牙机水路中不断生长和繁殖,口腔牙周治疗过程中产生气溶胶可能被吸入导致免疫力低下的人群呼吸道感染或直接污染引起牙龈创伤局部感染甚至导致全身感染<sup>[13-15]</sup>。临床中,部分护理人员只对超声洁牙机水路可更换部分进行更换,而未对整条水路管道进行消毒。本次研究发现,只更换部分管道而未进行其余管路消毒的对照组,其细菌菌落数一直处于超标状态,并且培养出鞘氨醇单胞菌、皮氏罗尔斯顿菌、哈特草螺菌3种细菌,可见临床上这种水路管道管理方法并不能有效控制水路中细菌含量。在研究过程中,3组洁牙机中途均再进行一次换管和换水,对出水口水样菌落数并无明



a-c: the number of bacterial colonies in the tube inner wall of experimental group 1 and experimental group 2 was significantly less than that of the control group from the front view of the wall. d-f: the thickness of the bacterial biofilms in the tubes of experimental group 1 and experimental group 2 was significantly lower than that of the control group from the cross section. g-i: there was obvious stripping of the biofilms on the inner surface of the pipes in experimental group 1 and experimental group 2, and the stripping of the biofilms in experimental group 2 was better than that in experimental group 1, while the stripping of the biofilms in the control group was not obvious. Control group: no disinfection treatment. Experimental group 1: 3% hydrogen peroxide. Experimental group 2: 500 mg/L chlorine-containing disinfectant

Figure 2 The tube inner wall biofilms in the experimental groups were observed under an electron microscope on the 10th day after disinfection

图2 实验组消毒后第10天扫描电镜下管道内壁生物膜观察

显影响。研究表明:3%过氧化氢溶液和500 mg/L的含氯消毒液在口腔综合治疗台水路管道中有较好的杀菌效果<sup>[16-20]</sup>。因此,本研究选择了以上两种临床常见的消毒剂对不可更换管道水路进行充分消毒<sup>[21-22]</sup>,在一定时间可降低水样中微生物载量,使细菌菌落数达标,在实验组消毒后即刻和第1、2天,均有水样中菌落数为0的良好结果,有效破坏了水管内壁生物膜结构,杀灭条件致病菌,提高治疗用水的质量。使用2种消毒方法后,电镜下生物膜的厚度较对照组变薄,提示使用两种消毒剂均可有效抑制生物膜的生成,减少原有生物膜的厚度,促进生物膜的剥离脱落。

### 3.2 两种消毒剂用于超声洁牙机水路的消毒时机

相关研究表明3%过氧化氢溶液和500 mg/L的含氯消毒液对于口腔牙椅水路消毒有一定的效果<sup>[16, 23-24]</sup>,但针对管道消毒的频次、间隔时间却少有研究,临床实际工作中,牙周超声洁牙机水路需要间隔多久消毒仍然不清楚。本研究连续取样11 d,通过对3组超声洁牙机水路连续监测发现:实验1组即3%过氧化氢溶液组,在常规更换无菌水源、无菌供水管、无菌工作头的情况下,应用3%过氧化氢溶液消毒水路管道中不可更换部分之后第3天出现工作端出水口水样细菌菌落数超标,与实验2组比较,差异有统计学意义。可见3%过氧化氢溶液能有效杀灭独立水路的细菌,但效果持续时间较短,需间隔一日再进行消毒。然而应用500 mg/L含氯消毒液消毒水路管道中不可更换部分则是在第7天出现出水口水样细菌菌落数超标,可以推断500 mg/L含氯消毒液能有效杀灭鞘氨醇单胞菌等细菌,且对其他2种细菌的抑菌效果明显,说明含氯消毒液具有对菌落生长的长效抑制作用,只需每周消毒1次即可,但是在使用含氯消毒液的过程中,应注意现配现用,使用前监测有效氯的含量,保证消毒效果的有效性,消毒后监测水中残余氯浓度,保持无菌治疗用水的最大纯度。

### 3.3 提倡合理使用消毒剂,精准感控

本研究证实,不论是使用3%过氧化氢溶液或者500 mg/L含氯消毒液进行水路消毒,都能有效杀灭管道中的细菌,保证水路的洁净。配合使用无菌水源、无菌供水管、无菌工作头虽然能够保证整个管道中可更换部分的清洁,但水路管道中不可更换部分依旧会在消毒之后数天内水样中细菌菌落数超标。临床上有多种消毒剂与消毒方法供

选择,每种消毒剂或者消毒方法都可能带来不同的消毒效果,仍需加强研究,科学选用适合且正确的超声洁牙机水路消毒管理办法,既能保证消毒效果,保障患者安全,同时也无需增加临床护理人员的工作量,做到精准感控,节约资源,保护环境。

综上所述,超声洁牙机独立水路存在污染滋生细菌的风险,应该重视并采取有效的消毒措施,并且在管理过程中要关注整体水路,在控制牙周超声洁牙机水路交叉感染的整个消毒体系中,如果其中一个环节未控制好,将导致整个水路消毒的失败。提示在临床工作中,在保证可更换管道无菌的情况下,应关注不可更换部分水路管道的消毒管理。采用3%过氧化氢溶液消毒牙周超声洁牙机独立水路建议隔日消毒1次;采用500 mg/L含氯消毒液则建议每周消毒1次。下一步可继续研究其他消毒剂,如过氧化氢银离子消毒液的消毒效果、持续时间及消毒频率等,为我国牙科超声治疗仪独立水路消毒试剂的选择和规范的水路消毒管理制度的制定提供参考。

**【Author contributions】** Hou YR designed the study, performed the experiments, analyzed the data and wrote the article. Ni J, Zhou QY, Gao YL, Chen XC performed the experiments and analyzed the data. Zhang XY designed the study and reviewed the article. All authors read and approved the final manuscript as submitted.

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