



Supplementary materials for

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Table S1 Tooth axis data statistics

Tooth	11	12	13	14	15	16	17	18
D_s	1493	1487	1475	1390	1473	1467	1486	49
D_l	12 945	12 854	12 836	12 086	12 776	12 807	12 875	425
Tooth	21	22	23	24	25	26	27	28
D_s	1495	1480	1489	1394	1469	1483	1488	45
D_l	12 938	12 848	12 852	12 115	12 761	12 829	12 887	455
Tooth	31	32	33	34	35	36	37	38
D_s	1435	1472	1496	1433	1480	1438	1484	108
D_l	12 519	12 731	12 942	12 434	12 747	12 458	12 859	926
Tooth	41	42	43	44	45	46	47	48
D_s	1443	1469	1493	1426	1471	1448	1486	100
D_l	12 514	12 686	12 940	12 404	12 754	12 477	12 856	945
Total	Number of patients				Total number of teeth			
D_s	1500				41 345			
D_l	12 991				358 481			

D_s : small dataset with 1500 patients; D_l : large dataset with 12 991 patients. Numbers denote the number of teeth for all the 32 permanent teeth

Table S2 Median, minimum, and maximum values of the predicted angle error from M_1^*

Tooth	11	12	13	14	15	16	17	18
X_e	2.912 (0.046,169.169)	4.611 (0.091,82.636)	4.808 (0.092,89.323)	4.390 (0.069,162.670)	4.743 (0.208,173.110)	3.171 (0.070,21.758)	4.980 (0.180,43.237)	7.379 (0.454,27.257)
Y_e	3.751 (0.01,169.205)	5.095 (0.074,82.329)	5.192 (0.018,94.202)	5.436 (0.108,174.843)	5.406 (0.107,175.475)	3.529 (0.176,21.737)	4.776 (0.058,45.350)	7.953 (1.595,27.317)
Z_e	3.606 (0.099,39.03)	3.954 (0.066,26.493)	4.246 (0.092,32.961)	4.736 (0.061,21.342)	4.220 (0.042,20.798)	2.981 (0.064,18.252)	4.538 (0.035,25.669)	6.346 (0.638,23.625)
Tooth	21	22	23	24	25	26	27	28
X_e	2.706 (0.083,29.762)	3.741 (0.049,93.034)	5.025 (0.194,176.393)	4.498 (0.041,134.101)	5.141 (0.128,177.909)	3.457 (0.081,46.210)	5.205 (0.156,32.971)	8.572 (2.070,32.767)
Y_e	3.564 (0.061,37.079)	4.329 (0.139,94.053)	5.495 (0.108,170.304)	4.972 (0.025,134.041)	5.296 (0.122,179.121)	3.709 (0.016,46.264)	5.237 (0.031,35.791)	8.188 (0.604,33.382)
Z_e	3.621 (0.028,37.122)	3.733 (0.051,26.943)	4.672 (0.127,23.516)	4.042 (0.060,16.953)	4.166 (0.056,18.895)	2.796 (0.065,17.317)	4.567 (0.109,34.909)	7.731 (0.336,27.128)
Tooth	31	32	33	34	35	36	37	38
X_e	2.685 (0.035,175.958)	2.815 (0.037,168.155)	5.259 (0.071,93.419)	5.916 (0.041,97.497)	6.187 (0.103,161.830)	4.034 (0.065,36.229)	4.982 (0.068,42.175)	7.976 (1.175,49.895)
Y_e	4.484 (0.039,175.593)	3.294 (0.086,172.086)	5.092 (0.084,98.343)	7.292 (0.097,97.500)	7.479 (0.156,161.395)	5.602 (0.057,32.079)	5.936 (0.112,42.525)	9.216 (1.215,49.414)
Z_e	4.385 (0.055,17.445)	3.358 (0.153,24.489)	4.016 (0.051,30.962)	5.593 (0.051,28.760)	5.878 (0.114,35.100)	4.079 (0.067,37.796)	4.777 (0.132,36.043)	7.871 (1.033,36.082)
Tooth	41	42	43	44	45	46	47	48
X_e	3.060 (0.087,176.259)	2.975 (0.090,27.096)	4.667 (0.061,129.802)	5.472 (0.144,57.370)	5.801 (0.050,113.022)	3.491 (0.070,40.726)	4.462 (0.097,33.189)	7.053 (0.497,44.636)
Y_e	3.579 (0.020,175.553)	4.161 (0.145,26.852)	4.627 (0.067,137.174)	6.783 (0.149,57.410)	8.159 (0.129,111.146)	4.425 (0.157,46.949)	5.680 (0.287,35.972)	7.366 (0.99,37.099)
Z_e	2.990 (0.126,19.251)	3.929 (0.044,17.935)	3.705 (0.061,32.717)	5.097 (0.074,33.246)	5.912 (0.028,38.105)	3.586 (0.002,30.816)	5.057 (0.044,29.027)	6.971 (0.318,33.576)

* Trained with weighted sum loss and tested on 2598 patients. X_e , Y_e , and Z_e denote angle errors along the X , Y , and Z axis, respectively; measured with degree. Bold numbers indicate the worst angle errors

Table S3 Average occlusal angle for teeth pairs*

Teeth	11&41	12&42	13&43	14&44	15&45	16&46	17&47	18&48	21&31
δ_a	39.51	42.15	40.96	22.73	21.13	NA	NA	NA	42.50
δ_a'	39.15	34.81	36.94	17.10	13.49	10.83	12.94	21.45	39.50
$\delta_a - \delta_a'$	0.36	7.34	4.02	5.63	7.64				3.00
Teeth	22&32	23&33	24&34	25&35	26&36	27&37	28&38	ALL pairs	
δ_a	38.18	44.23	19.68	17.60	NA	NA	NA	38.41	
δ_a'	33.29	38.41	16.00	13.49	10.00	12.36	18.26	26.01	
$\delta_a - \delta_a'$	4.89	5.82	3.68	4.12				12.40	

* Test on 128 patients with non-inflammatory gingival atrophy. δ_a and δ_a' are the angle differences along the axial plan (Z axis) of each paired occlusal teeth from patients with or without gingival atrophy, respectively; measured with degree. Some paired teeth do not exhibit non-inflammatory gingival atrophy in our dataset and are marked. NA: not applicable. "ALL pairs" contains all the pairs with atrophy

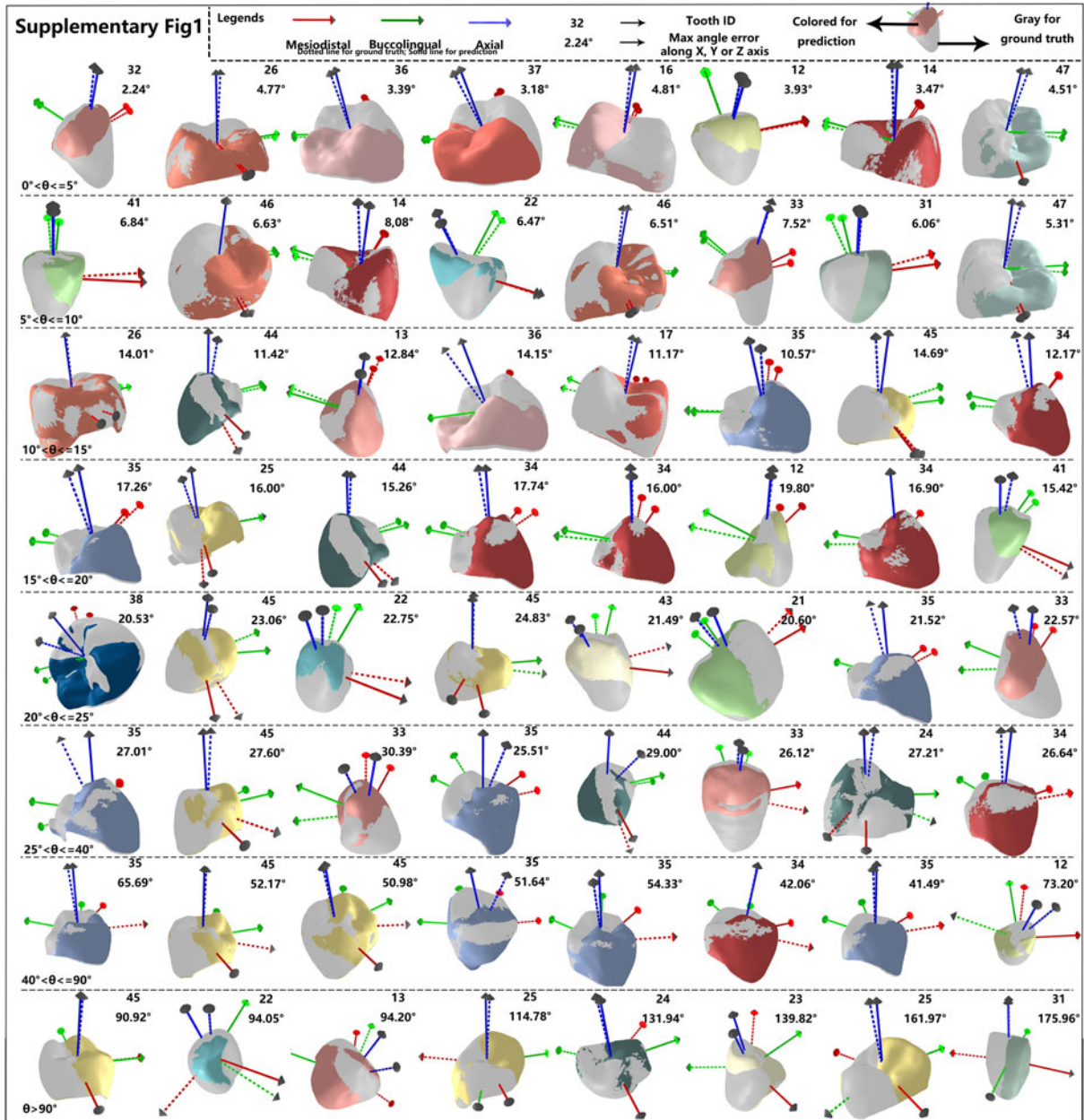
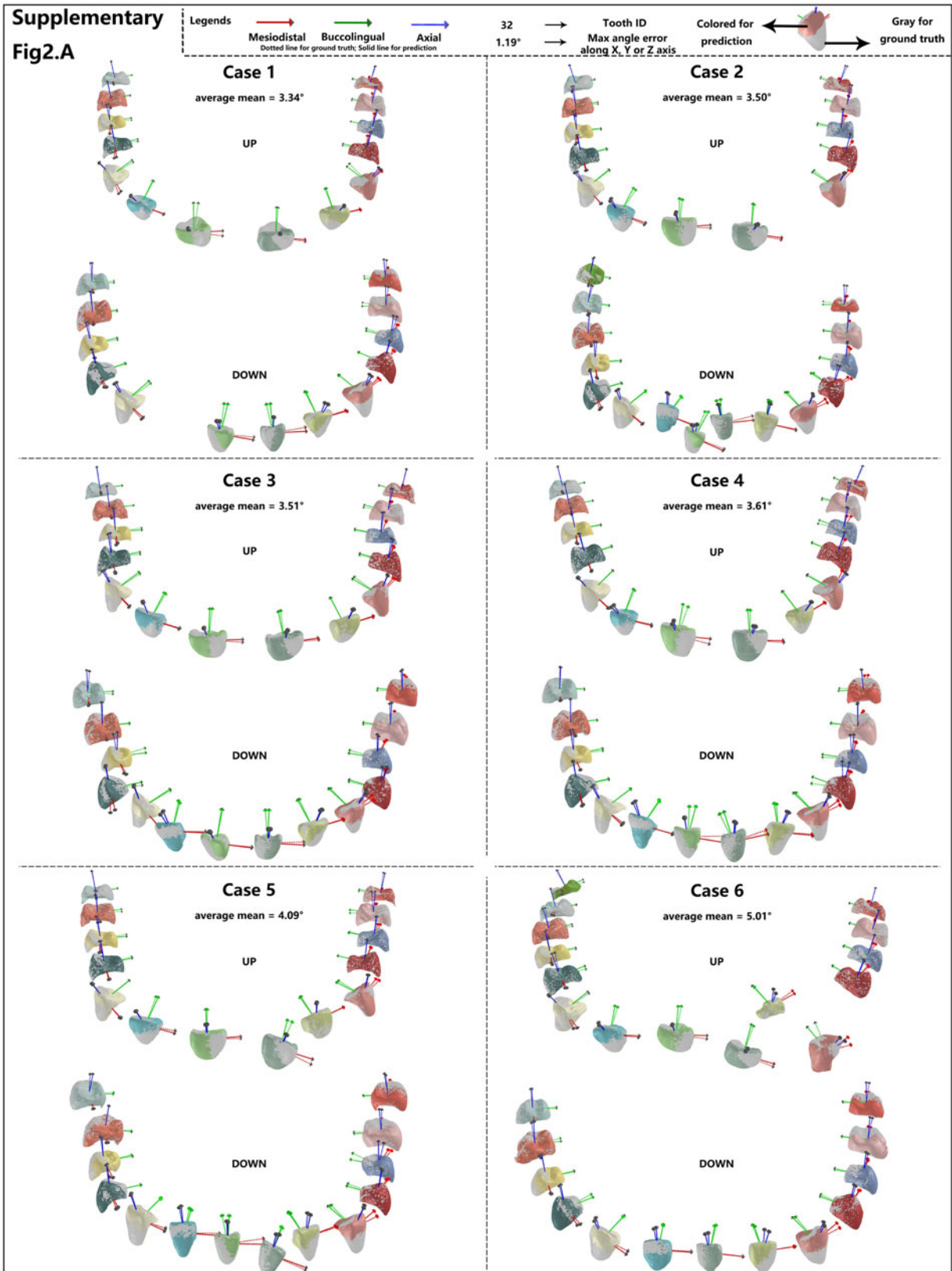


Fig. S1 Visualization of estimated orientation and ground truth for Example 1



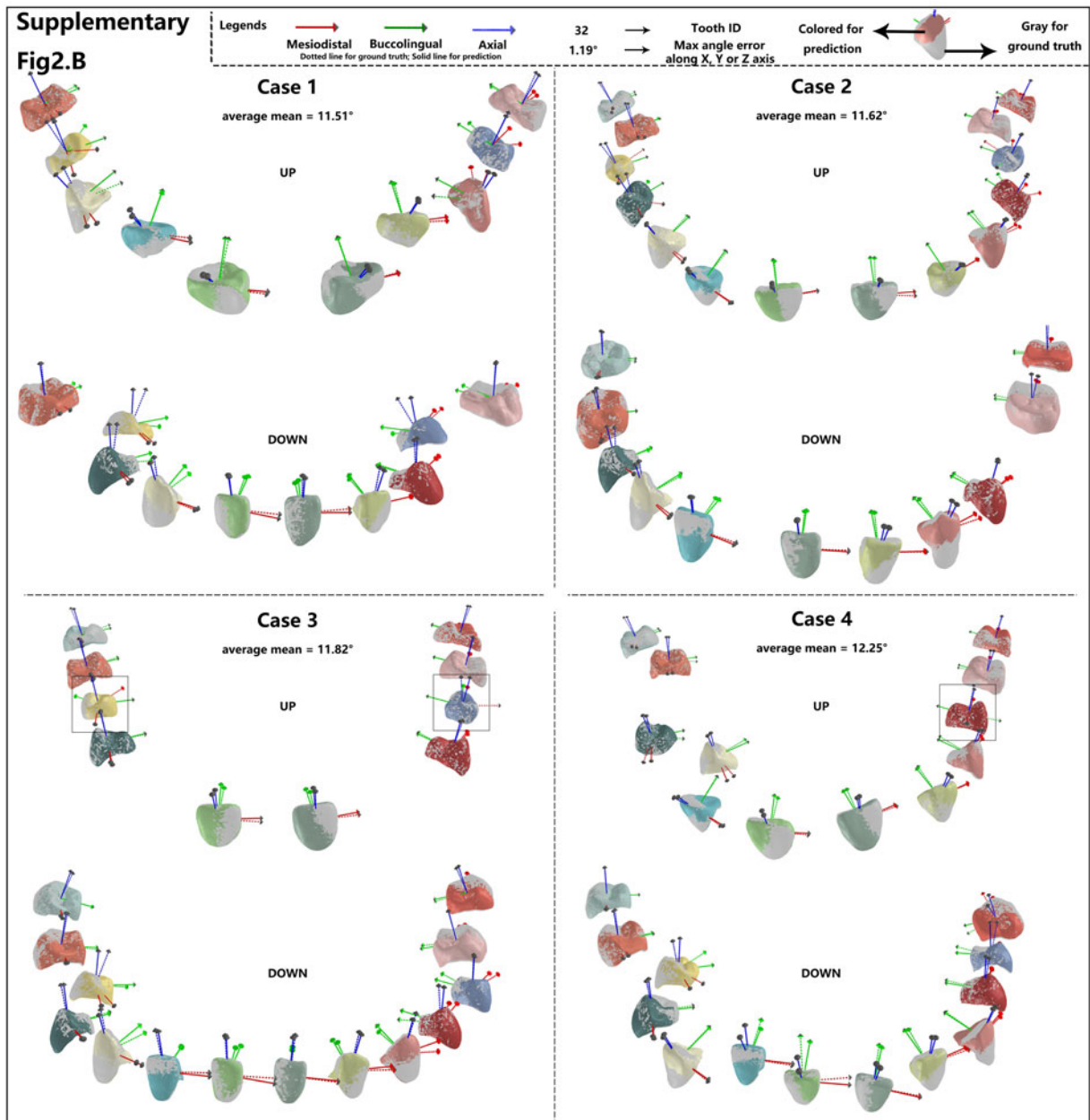


Fig. S2 Visualization of estimated orientation and ground truth for Example 2