ORIGINAL RESEARCH

Assessment of Undercuts Relative to Abutment Teeth and Edentulous Area: A Retrospective Cross-sectional Study

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Abstract

Aim: Undercuts on abutment teeth (AT) should be identified and quantified to establish the exact location of the active tip of the retentive arm of the direct retainer. The aim of this study was to locate and evaluate tissue and tooth undercut areas in various Kennedy's classes and to assess the correlation, if any, between Kennedy's classes and the location and depth of undercuts.

Materials and methods: One hundred and seven patients' casts, with designated AT and edentulous areas (EAs), were surveyed. The undercuts on AT and EAs were measured using undercut gauges. Statistical analysis was performed.

Results: The median depth of the undercut was maximum on distal the surface of mandibular AT in a Kennedy's class III edentulous situation. No significant difference was found between the amount of tissue undercuts measured on the EA in each of the Kennedy's classes in the maxillary and mandibular arches.

Conclusion: No significant difference was found between the amounts of undercut measured on AT and the EA in each of the Kennedy's classes in the maxillary and mandibular arches. No correlation was found between Kennedy's classes and the location and depth of undercuts.

Clinical significance: The results of our study reinforce that the diagnosis and selection of ideal abutments should be stressed while planning for a removable dental prosthesis (RDP). In the majority of the cases, the anticipated design of the direct retainer can be applied, though one cannot overlook the need for proper diagnosis and survey.

Keywords: Abutment tooth, Direct retainer, Removable partial denture, Retrospective study, Undercut.

The Journal of Contemporary Dental Practice (2020): 10.5005/jp-journals-10024-2728

Introduction

Rehabilitation of partially edentulous patients by a removable dental prosthesis (RDP) is a common treatment option in developed countries.[1] Planning for RDP should be done in such manner that there is minimum damage to adjacent teeth and underlying tissues.

In 1923, Dr Edward Kennedy partially classified the edentulous arches in a way that suggests certain principles of design for a given situation.[2] The location and number of edentulous areas (EAs) play a preeminent role in designing RDPs. Gomes et al.[3] suggested that one of the most important factors in the fabrication of removable partial dentures is the selection, distribution, and location of abutment teeth (AT). The selection of a direct retainer for an RDP depends on the location and depth of the undercuts on AT. Undercuts on AT should be identified and quantified to establish the exact location of the active tip of the retentive arm of the direct retainer. This procedure is important for obtaining appropriate prosthesis retention during gingivo-occlusal movement and effective reciprocity of the clasp during function. The depth and location of tissue undercuts in EAs are also important, as they may play a pivotal role in deciding the placement path of an RPD.

No studies are available in the literature that show any direct correlation between the location and severity of undercuts in different Kennedy's classes. The aim of this study was to locate and evaluate tissue and tooth undercut areas in various Kennedy's classes. This study also assessed for correlation, if any, between Kennedy's classes and location and depth of undercuts, as this may help in proper designing of RDPs. The null hypothesis stated that there would be a significant correlation between Kennedy's classes and the location and depth of undercuts.

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How to cite this article: Sayed M, Jameel A, Duhduh G, *et al.* Assessment of Undercuts Relative to Abutment Teeth and Edentulous Area: A Retrospective Cross-sectional Study. J Contemp Dent Pract 2020;21(1):41–46.

Source of support: Nil

Conflict of interest: None

Materials and Methods

This retrospective cross-sectional study was performed at the Department of Prosthetic Dental Sciences, College of Dentistry, Jazan University. Two hundred and fifty partially edentulous patients were randomly selected by three authors (MS, AJ, and SJ) from a partially edentulous patient pool at the College of Dentistry. Diagnostic stone casts of these patients were collected from the production lab of the college. These casts were obtained by making primary impressions of partially edentulous patients who visited dental clinics from February 1, 2018 to May 31, 2018, for replacing the missing teeth by an RDP. Impressions were made by 5th- and 6th-year undergraduate students (under the supervision of trained prosthodontists) using irreversible hydrocolloid impression material

in a perforated metal stock tray by following the manufacturer's instructions. All casts were poured by a trained dental technician using type III dental stone by following the manufacturer's instructions by using a vacuum mixer and a laboratory vibrator.

Medical and personal data of these selected, 250 patients, were collected from college records (R4 electronic record system). These patients were invited for a follow-up visit by telephone calls. Ethical approval of the study protocol was reviewed and approved by the Institutional Review Board and Ethics Committee. Before initiating the study, an informed consent was obtained from all the selected patients. Three authors (MS, AJ, and SJ) individually screened these 250 patients and their casts, based on predefined inclusion and exclusion criteria (Table 1). Finally, a total of 107 patients' casts were selected for this study (Flowchart 1).

Two trained prosthodontists (MS and AJ) individually analyzed each selected cast under a dental surveyor, and RDP was designed to determine the potential AT and the existing EAs. κ scores (Cohen κ coefficient, $\kappa = 0.928$) indicate near perfect agreement between the three prosthodontists. Two examiners (MS and AJ) were trained and calibrated, and a pilot study was conducted to assess the intra- and interexaminer measurement variability. Intra- and interexaminer reliability and reproducibility were evaluated using intraclass correlation coefficient (ICC) and intraclass correlation coefficient reproducibility (ICCR) tests on SPSS 20 statistics software (SPSS Inc., Chicago, IL). The intra- and interclass correlation coefficient values were 0.971 and 0.983, respectively.

The cast with designated AT and EA was mounted on a dental surveyor with an occlusal plane parallel to the horizontal plane. The undercuts on AT were measured at three locations [mesial (M), midfacial (MF) and distal (D)] using the standard undercut gauges (0.01, 0.02, and 0.03 inches) (Fig. 1). The EA was designated and measured linearly by drawing a line in the middle of the crest of the ridge. The measured length of the EA is then bifurcated and marked with a pencil. This marked tissue area is measured for existing tissue undercuts using the standard undercut gauges (Fig. 2). Each patient's personal details, Kennedy classification for EA, the number of AT, and the severity of tooth and tissue undercuts were duly recorded simultaneously by examiners.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	*Exclusion criteria*
Male and female patients of age between 18 years and 50 years	Tilted teeth (>25°)
Partially edentulous maxillary and/or mandibular arch requiring removable dental prosthesis	Rotated teeth
No relevant medical problem	Supraerupted teeth
No habits	Presence of gingival enlargement
	Severe attrition of teeth
	Restored abutment teeth
	Mobile teeth
	Altered axial contours of teeth by direct or indirect restorations

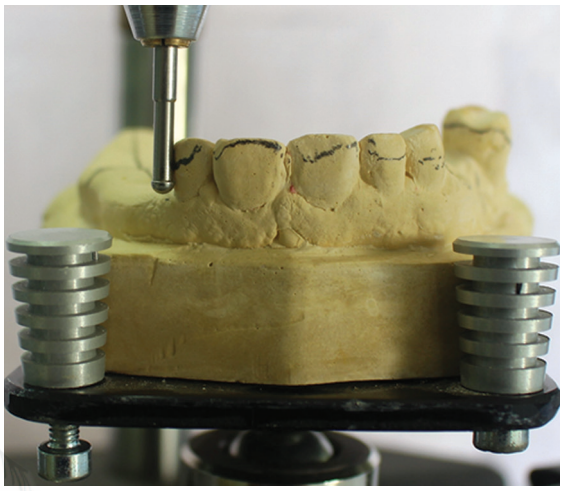
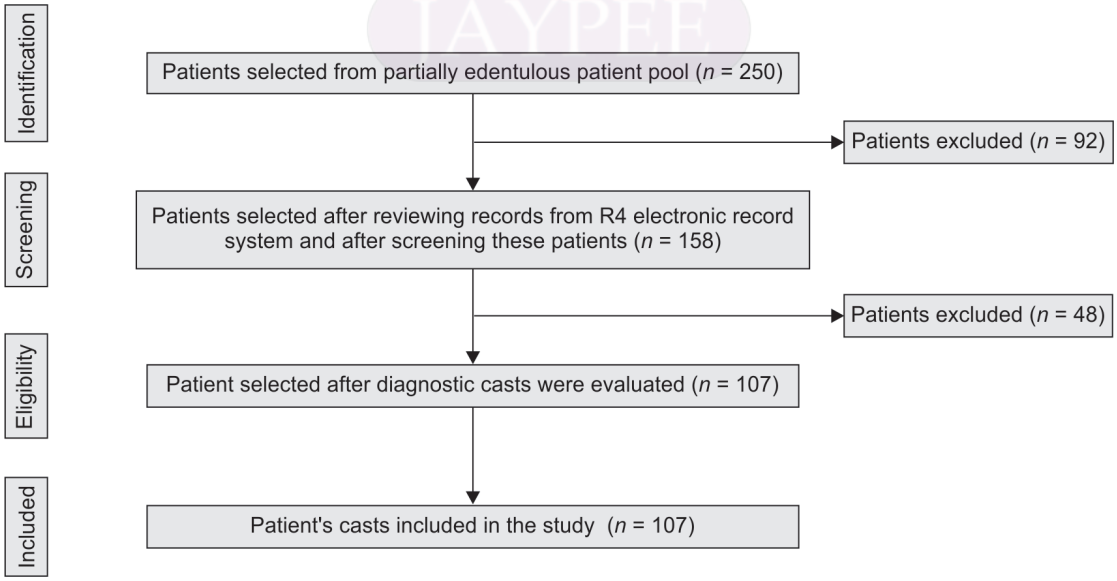


Fig. 1: Assessment of undercut on abutment tooth

Flowchart 1: Patient selection strategy



Data Analysis/Statistics

Collected data were simultaneously tabulated in a Microsoft Excel spreadsheet (Microsoft Inc., Redmond, WA), and statistical analysis was performed using software SPSS 20 for Windows (SPSS Inc., Chicago, IL). The association between the location of undercuts in various Kennedy's classes and the amount of tooth undercut measured was determined by using a Kruskal–Wallis analysis of variance test. The association between various Kennedy's classes and the amount of EA undercut measured was determined by using the Chi-square test. For all the performed analyses, a *p* value <0.05 was regarded as statistically significant.

Results

This study used 107 diagnostic casts of partially edentulous patients. Fifty-five patients (51.4%) were between 25 years and 45 years of age, 44 (41.12%) were above 45 years of age, and 8 (7.48%) were of 18–25 years of age (Table 2 and Fig. 3). Sixty-five patients (60.75%) were females and 42 (39.25%) were males. Of these 107 patients' casts, 66 (61.68%) had no modification spaces, while 41 (38.32%) had modification spaces (Table 2 and Fig. 3). Fifty-six patients (52.34%) had Kennedy's class III (33 in the maxillary arch and 23 in the mandibular arch), 25 (23.36%) had class II (11 in the maxillary arch and 14 in the mandibular arch), 21 (19.63%) had class I (17 in the maxillary arch and 4 in the mandibular arch), and only 5 patients (4.67%) had class IV (all in the maxillary arch) edentulous situations (Table 3).

A total of 296 ATs were evaluated for undercuts. Of these, 142 (47.9%) were in the maxillary arch and 154 (52.1%) in the mandibular arch. One hundred and sixty-five (55.7%) AT checked were of Kennedy's class III; and of these, 72 (43.6%) were in the maxillary

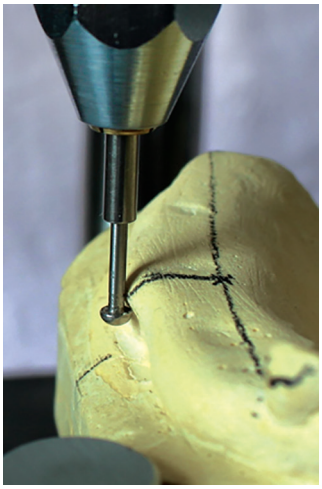


Fig. 2: Assessment of undercut in edentulous area

Table 2: Distribution of respondents by age-groups, gender, Kennedy classification, and modification

Factors	*Number of respondents*	*% of respondents*
Age-groups		
18–25	8	7.48
25–45	55	51.40
>45	44	41.12
Gender		
Male	42	39.25
Female	65	60.75
Kennedy classification		
I	21	19.63
II	25	23.36
III	56	52.34
IV	5	4.67
Modification		
No	66	61.68
Yes	41	38.32
Total	107	100.00

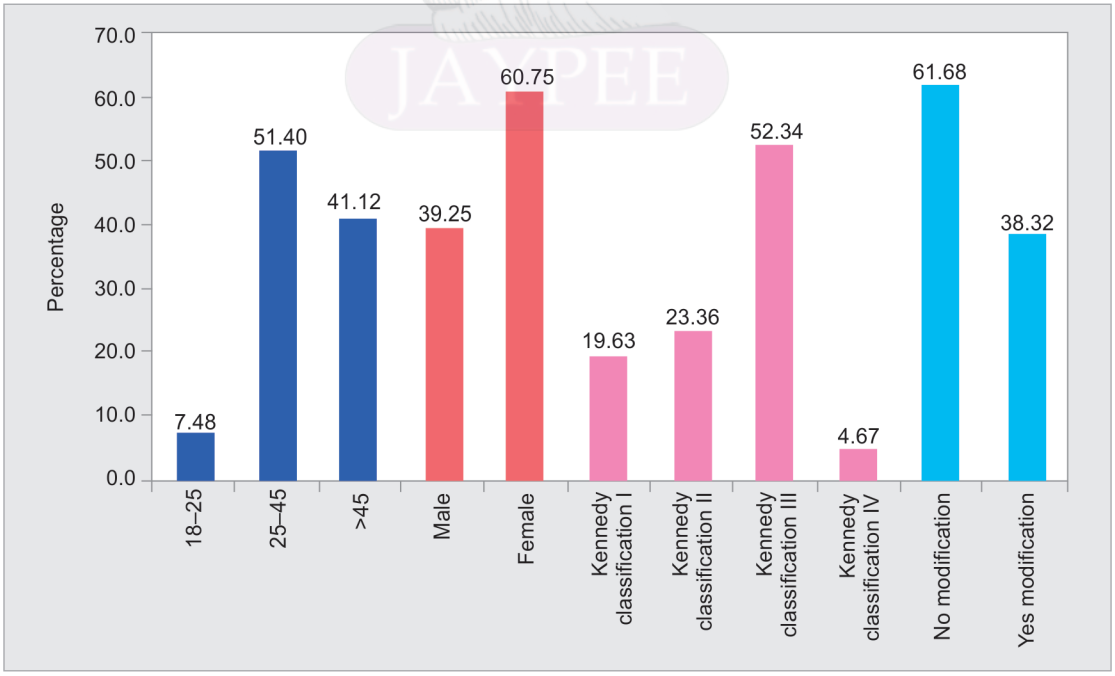


Fig. 3: Distribution of respondents by age-groups, gender, Kennedy classification, and modification

Table 3: Number of samples in each Kennedy's class in maxillary and mandibular arches

	Kennedy's classification				
	I	*II*	*III*	*IV*	*Total*
Number of tooth abutment in	*Modification*	*Modification*	*Modification*	*Modification*	*Modification*
Maxillary	17	11	33	5	66
Mandibular	4	14	23	0	41
Total	21	25	56	5	107

Table 4: Number of abutment in each Kennedy's class in maxillary and mandibular arches

	Kennedy's classification				
	I	*II*	*III*	*IV*	*Total*
Number of tooth abutment in	*Modification*	*Modification*	*Modification*	*Modification*	*Modification*
Maxillary	41	19	72	10	142
Mandibular	13	48	93	0	154
Total	54	67	165	10	296

arch and 93 (56.4%) in the mandibular arch. Sixty-seven (22.6%) AT checked were of Kennedy's class II. Of these, 19 (28.3%) were in the maxillary arch and 93 (71.7%) in the mandibular arch. Fifty-four (18.2%) AT checked were of Kennedy's class I. Of these 41 (75.9%) were in maxillary arch and 93 (24.1%) in mandibular arch. Ten (3.3%) AT were of Kennedy's class IV, all of which were the in maxillary arch (Table 4).

The amount of undercut present in each tooth was measured and tabulated (Table 5). No significant difference was found between the amounts of undercut measured at all three surfaces on AT in each of the Kennedy's classes in the maxillary and mandibular arches. However, the median depth of undercut was maximum (0.003 inch) on the distal surface of mandibular AT in Kennedy's class III edentulous situation. The median depth of undercut was higher (0.002 inch) on the mesial surface of mandibular AT in Kennedy's class I and the distal surface of mandibular AT in the Kennedy's class II edentulous situation. The median depth of undercut was minimum (0.001 inch) on the distal and midfacial surfaces of maxillary AT in Kennedy's class II, the midfacial surfaces of maxillary AT in Kennedy's class III, and the midfacial surfaces of mandibular AT in the Kennedy's classes I and II edentulous situation. The interquartile range (IQR) was the highest for the mesial surface of the abutment tooth in Kennedy's class I situation (0.001 inch) in both the maxillary and mandibular arches, while the lowest IQR was seen on M of classes II and III and MF and D of the Kennedy's class IV situation.

Table 6 shows the association between the Kennedy's classes with the measurement of EA undercut. No significant difference was found between the amount of tissue undercuts measured on the EA, in each of the Kennedy's classes in maxillary and mandibular arches ($p > 0.05$). Seventy-five percent of the EA in Kennedy's class III situation has less than a 0.01 inch undercut, while 5.36% has greater than a 0.03-inch undercut. 61.9% of the EA in Kennedy's class I situation has less than a 0.01-inch undercut, while no surface had greater than a 0.03-inch undercut. In the Kennedy's class II situation, 60% of EA has less than a 0.01-inch undercut, while 4% has more than a 0.03-inch undercut. In Kennedy's class IV, 20% of EA has less than a 0.01-inch and more than a 0.03-inch undercut.

Discussion

The aim of this retrospective study was to locate and evaluate tissue and tooth undercut areas in various Kennedy's classes for partially edentulous arches. This study also assessed for correlation, if any, between Kennedy's classes and the location and depth of undercuts. To the best of our knowledge, this study is the first of its kind per the searched indexed English literature review. The results of the present study supported rejection of the null hypothesis.

Retention is one of the basic requirements of properly designed direct retainers of a removable partial denture.[4] A dental surveyor is used to survey the diagnostic cast and locate retentive areas on the remaining teeth. McCracken stated that, "uniform retention, disregarding flexibility, depends upon the location of the clasp tip, not in relation to the height of contour but in relation to the depth of undercut."[5] Study by Avant showed that the retention of the clasp increases as the vertical distance of the clasp tip cervical to the height of contour decreases.[6] On the contrary, various other studies in the literature state that retentive forces directly depend on the depth of the undercut, not on the distance, the clasp is located vertically below the survey line.[7,8] The retentive tip of the direct retainer is placed in the undercut areas to prevent the movement of prosthesis in occlusal direction. The location and depth of the undercuts on the AT play important roles in designing RDPs. Retentive areas were shown to be more stable when they were located in enamel as compared to when located in restored surfaces.[9] The selection of the type and material of a direct retainer depends on the location and depth of the undercuts on the AT.[10] The basic aim is to select the correct design, material, and location of the retainer, so that it provides adequate retention without jeopardizing the life of the AT.[4]

The findings of the present study suggest no significant difference between the amounts of undercut measured at any of the three surfaces of AT in each of the Kennedy's classes in the maxillary and mandibular arches. On most of the surfaces evaluated, the median depth of the undercut was 0.002 inches. Most of the suitable undercuts in classes I and II were present on the midfacial surface; thus, these teeth are suitable for using rest, proximal plate and I bar (RPI) clasps (where I bar is placed in the midfacial region), which is mostly indicated in Kennedy's classes I and II edentulous situations.[4] The median depth of the undercut was maximum (0.003 inch) on the distal surface of the mandibular AT in Kennedy's class III edentulous situation.

The presence of undercuts in EAs can influence the design of the RDP.[11–13] Severe undercuts can unilaterally or bilaterally complicate the successful fabrication of the RDP. Various methods

Table 5: Measurement of tooth undercut (amount) in inches, in Kennedy's class in maxillary and mandibular arches by Kruskal–Wallis ANOVA

		Amount of tooth undercut (in inches) in Kennedy's classification									
		I		*II*		*III*		*IV*			
	Location of tooth undercut	*Median*	*IQR*	*Median*	*IQR*	*Median*	*IQR*	*Median*	*IQR*	*H value*	*p value*
Maxillary arch	M	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.005	2.2820	0.5160
	MF	0.02	0.00	0.01	0.01	0.01	0.005	0.02	0.00	1.4160	0.7020
	D	0.02	0.01	0.01	0.005	0.02	0.00	0.02	0.00	3.8290	0.2800
Mandibular arch	M	0.02	0.0075	0.02	0.005	0.02	0.00	–	–	1.3570	0.5070
	MF	0.01	0.01	0.01	0.005	0.02	0.005	–	–	1.9090	0.3850
	D	0.02	0.0025	0.02	0.0025	0.03	0.005	–	–	1.7240	0.4220
Total maxillary + mandibular	M	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.005	2.9730	0.3960
	MF	0.01	0.005	0.01	0.005	0.01	0.005	0.02	0.00	1.7310	0.6300
	D	0.02	0.005	0.02	0.005	0.02	0.005	0.02	0.00	0.8210	0.8440

ANOVA, analysis of variance; IQR, interquartile range

Table 6: Association between Kennedy classification and measurement of EA undercut (in inches)

Factors	*<0.001*	*%*	*0.001*	*%*	*0.002*	*%*	*0.003*	*%*	*>0.003*	*%*	*Total*	*Chi-square*	*p value*
Kennedy classification													
I	13	61.90	5	23.81	3	14.29	0	0.00	0	0.00	21	18.8188	0.0931
II	15	60.00	5	20.00	3	12.00	1	4.00	1	4.00	25		
III	42	75.00	4	7.14	4	7.14	3	5.36	3	5.36	56		
IV	1	20.00	3	60.00	0	0.00	0	0.00	1	20.00	5		

EA, edentulous area

are mentioned in the literature to manage these tissue undercuts, including surgical corrections,[11] rotational paths of insertion, and the use of resilient lining materials.[12]

The findings of this study suggest no significant difference between the amounts of tissue undercut measured at the center of the EA in each of the Kennedy's classes, in both maxillary and mandibular arches ($p > 0.05$). Most of the EAs have tissue undercuts of less than 0.01 inches. In Kennedy's class IV, 20% of the EA has greater than 0.03 inch undercut. Various methods should be used to manage these undercuts for the fabrication of a successful RDP.

The findings of our study differed from the basics of Kennedy's classification. The numeric sequence of Kennedy's classification was based partly on the frequency of occurrence, with class I arches being most common and class IV arches least common.[14] Study by Keyf[15] analyzed the distribution of partial edentulous patients using Kennedy classification and found that class I had the largest distribution, while class IV had the least distribution. However, in our study, after random selection of partially edentulous patients, we found that Kennedy's class III situation is most prevalent (52.3%) followed by class II (23.3%), class I (19.6%), and class IV (4.6%).

Conclusion

Within the limitations of this study, it can be concluded that

- No significant differences were found between the amounts of undercut measured on AT and the EA in each of the Kennedy's classes in the maxillary and mandibular arches.
- No correlations was observed between Kennedy's classes and the location and depth of undercuts.

Limitation of this study is that the soft tissue undercuts were measured only at a predefined area. Further studies are required, which can measure the soft tissue undercuts at multiple locations.

Clinical Significance

The results of our study reinforce that the diagnosis and selection of ideal abutments should be stressed while planning for an RDP. If there is an ideal abutment, we can anticipate no much difference in the amounts of undercuts in the AT and in the EAs in both the maxillary and mandibular arches. In the majority of the cases, the anticipated design of the direct retainer can be applied, though one cannot overlook the need for proper diagnosis and surveying.

Manufacturer's Details

- Irreversible hydrocolloid impression material: Tropicalgin, Zhermack, Italy
- Perforated metal stock tray: GC Corp., Tokyo, Japan
- Type III dental stone: Lab Stone; Dentsply, York, PA
- Vacuum mixer: Mix-R; Dentalfarm, Torino, Italy
- Laboratory vibrator: Mini Export; Dental farm
- Dental surveyor: A3005; Surveyor Type A; Dentalfarm, Turin, Italy

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