CLASSIC ARTICLE

Fundamentals of extracoronal tooth preparation. Part I. Retention and resistance form

Dennis B. Gilboe, DDS,[a] and Walter R. Teteruck, DDS, MSD[b]
College of Dentistry, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

The differential selection and application of retention and resistance form in tooth preparation depend upon the individual clinical situation. Since the "textbook ideal" is not often encountered clinically, knowledge of basic principles and factors is mandatory for the successful preparation of extracoronal restorations.

Black[1] astutely recognized and stressed the importance of these two basic characteristics. He stated: "Resistance form is that shape given to a cavity intended to afford such a seat for the filling as will best enable it to withstand the stress brought upon it in mastication. Retention form is the provision for preventing it from being dislodged."

More recent concepts tend to emphasize the duplication of a preconceived design of a preparation rather than the assessment of biomechanical requirements of individual retainers. The modification of an ideal design for a preparation entails judgment in the application of the basic principles of retention and resistance (Table I). An analysis of these principles and factors should enable the dentist to effectively apply them during the design of any preparation. The ability to cope with atypical clinical situations is markedly enhanced by such organized application.

All preparations require the incorporation of factors to prevent the dislodgment of the restoration by functional stresses. Retention form counteracts tensile stress, and resistance form counteracts shearing stress (Fig. 1).[2] A preparation with good resistance form will be retentive; the opposite is not necessarily true.[3] The same method is often used when incorporating the factors of both retention and resistance form. Thus, for practical purposes, these factors can be considered together (Fig. 2).

PRIMARY FACTOR—AXIAL SURFACES

Parallelism. As the axial walls approach parallelism, the restoration can withstand greater displacement from tensile and shearing stresses (Fig. 3).[4-6] Axial surface reductions, within 2 to 5 degrees of parallelism with the path of withdrawal of the preparation, provide optimal resistance and retention. This convergence facilitates technical procedures and eliminates inadvertent undercuts. Axial surface reduction approaching parallelism produces opposition to displacement that is substantially more effective than any other factor.[6] Thus, in clinical situations (i.e., short teeth), the need for maximal resistance and retention form is obvious. The prepared axial surfaces must be as close to parallel as is clinically feasible (Fig. 3).

Length. As the length of the axial walls of the preparation increases, the resistance and retention form increase (Fig. 4).[6] The maximum length of the axial walls is maintained during preparation by removing minimal occlusal or incisal tooth structure to provide adequate bulk of restorative material for occlusion. Preservation of the inclined planes of the occlusal surfaces and the incisal angles of anterior teeth is the primary factor affecting this objective. The surgical repositioning of the marginal gingiva apically becomes unnecessary when the retention and resistance form can be achieved through the effective application of the primary factors alone or in conjunction with any or all of the secondary factors.

Surface area. A direct relationship exists between surface area and the retentive-resistance potential of the retainer.[6] The larger the cervical diameter of the tooth, the greater the surface area available to be included in the preparation. Thus, the greater the circumference of the tooth, the greater the potential resistance of the retainer to dislodgment. Also, by increasing circumferential involvement through the addition of axial walls, retention and resistance are increased (Fig. 5).

SECONDARY FACTORS

If the primary factor and its utilization are insufficient, secondary factors should be incorporated. The principles of parallelism, length, and surface area, already considered for the primary factor, also influence the secondary factors' effectiveness. Secondary factors should be placed within 2 to 5 degrees of parallelism with a primary or another secondary factor for maximum

---

[a]Assistant Professor.

[b]Associate Professor and Chairman, Division of Fixed Prosthodontics, Department of Restorative Dentistry, University of Western Ontario, London, Ont., Canada.

Reprinted with permission from J Prosthet Dent 1974;32:651-6.
J Prosthet Dent 2005;94:105-7.

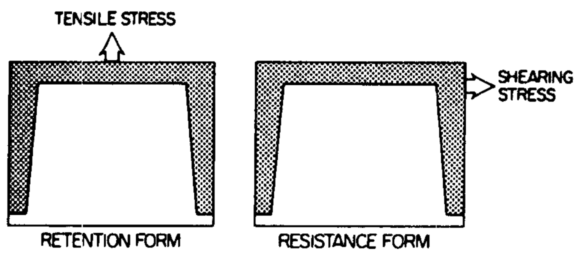

Fig. 1. Retention and resistance form.

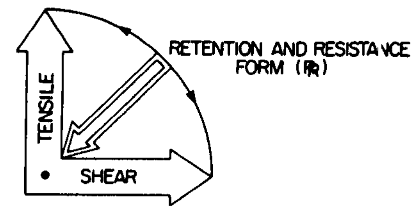

Fig. 2. Stress range of retention and resistance form.

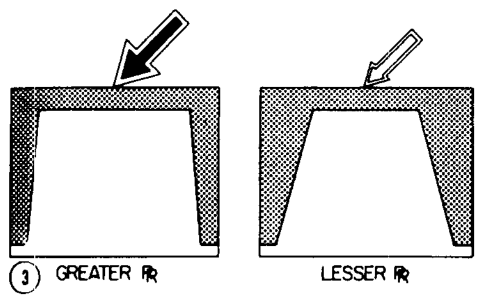

Fig. 3. Retention and resistance increase as length of axial walls increases.

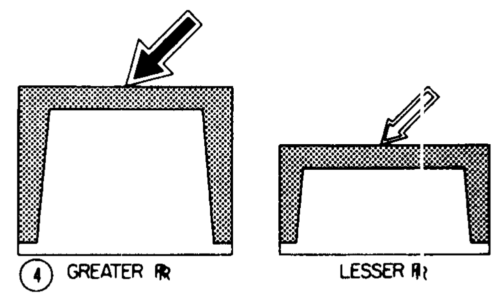

Fig. 4. Resistance and retention increase as length of axial walls increases.

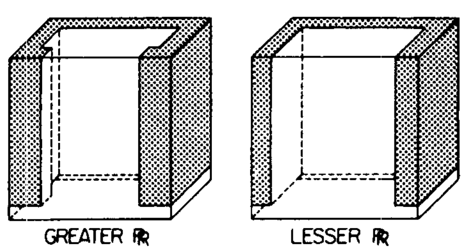

Fig. 5. Retention and resistance increase as circumferential involvement increases.

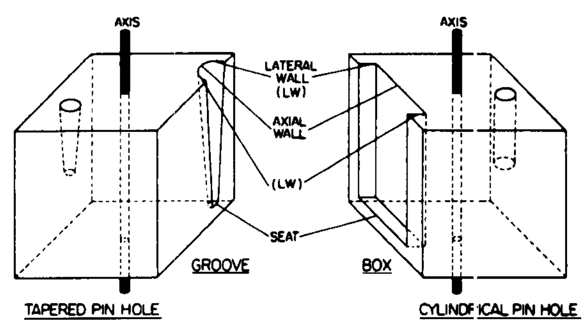

Fig. 6. Secondary factors increase retention and resistance.

Table I. Principles and factors in retention and resistance form

I. Principles
1. Parallelism
2. Length
3. Surface area
II. Factors
1. Primary factor—axial surfaces
2. Secondary factors
a. Groove
b. Box
c. Pinhole
d. Combinations of a, b, and c

effectiveness. Normally, this position is perpendicular to the direction of shear stress.

The secondary factor should be located (1) with the line of withdrawal, (2) as far as possible from its reciprocal retentive feature, and (3) at a point which permits the maximum length. The appropriate factor to be incorporated is the one which resists the displacing forces while conserving the greatest amount of structure.

Groove. The groove is the secondary factor which best achieves resistance form while conserving maximum tooth structure. It is, thus, the most commonly incorporated secondary factor.

Box. The box may be regarded as a wide groove with an increased surface area.

Pinhole. The pinhole may have tapered or parallel walls. Both types contribute more toward retention than resistance. The amount of retention is directly related to the area of the pin contacting the tooth and to the intimacy of the contact.[7] Retention is a function of the length and diameter of the pin. The pin is most vulnerable when subjected to shearing stress. Therefore, bulk is always necessary adjacent to the body of the

Table II. Application of principles and factors

Problem*	Correction	
Inadequate retention and resistance form	Compensatory principle (increase)	Compensatory factor (add)
Parallelism	Length	Groove Box Pin
Length	Parallelism Surface area	Pin
Surface area	Surface area	Groove Box Pin

*Inadequate retention and resistance form.

casting. Pins alone should not be depended upon for resistance form.[8]

Secondary factors must have sufficient axial depth for adequate breadth of the lateral retentive wall. A definite gingival seat will also provide greater surface area for the lateral retentive wall and enable the axial wall to have minimal divergence from parallelism. Reciprocal parallelism should exist among lateral retentive walls, axial walls, and axial surfaces. Secondary factors should be located as far as possible from their reciprocal retentive features and positioned so as to achieve maximal length (Fig. 6).

DIFFERENTIAL INCORPORATION OF THE PRINCIPLES OF RESISTANCE AND RETENTION

Parallelism of primary and/or secondary factors produces significantly greater opposition to displacement than is produced by any other principle. Thus, it is the optimal means to effective retention and resistance form unless it seriously violates conservation of tooth structure. Taper of the preparation may exceed 5 degrees only if inordinate length is present. Otherwise, secondary factors should be employed to achieve the necessary retention and resistance.

All teeth possess inherent length which can be preserved by controlled occlusal reduction. The principle of increasing the length of axial surfaces augments resistance and retention. Effective substitution or addition of a secondary factor frequently enables the preparation to terminate supragingivally. With the exception of the proximal surfaces, subgingival extension should be avoided to maintain both accuracy in marginal finishing and periodontal integrity.[9-11]

Increasing the surface area increases retention and resistance. A lack of surface area can only be compensated for through addition of the same. Increasing surface area by a primary factor will automatically involve a greater inclusion of axial surfaces, either apically or circumferentially. Therefore, conservation of tooth structure and the avoidance of subgingival margins limit the potential of this principle unless it can be achieved intracoronally by secondary means.

Secondary factors should be placed within 2 to 5 degrees of parallelism. They also should be located the greatest distance possible from another factor and positioned to achieve greatest length. Modification within esthetic limits may be necessary to fulfill these objectives. All secondary factors can partially compensate for inadequate parallelism, length, and surface area. Only pins can augment length.

The correction of inadequate retention and resistance form should always be attempted first through the application of compensatory measures (principles) to the primary factor (axial walls) and then, if necessary, through the addition of secondary factors (Table II)

SUMMARY

1. The principles and factors of retention and resistance form have been classified and discussed.

2. A basis for the selection and application of these principles and factors to fulfill the biomechanical requirements of individual retainers has been presented.

3. Adequate resistance and retention can be achieved during tooth preparation if a systematic approach, as outlined, is applied.

REFERENCES

1. Black GV. Operative dentistry. Chicago: Medico-Dental Publishing; 1908. vol. 2.
2. Guver SE. Multiple preparations for fixed prosthodontics. J Prosthet Dent 1970;23:529-53.
3. Rosentiel E. The retention of inlays and crowns as a function of geometrical form. Br Dent J 1957;103:388-94.
4. Jones WE. The scientifically designed partial veneer crown. J Am Dent Assoc 1973;86:1337-43.
5. Jorgensen KD. The relationship between retention and convergence angle in cemented veneer crowns. Acta Odontol Scand 1956;13:35-40.
6. Kaufman EG, Coelho AB, Colin L. Factors influencing the retention of cemented gold castings. J Prosthet Dent 1961;11:486-502.
7. Courtade GL, Timmermans JJ. Pins in restorative dentistry. St. Louis: Mosby; 1961.
8. Baum L, Contino RM. Ten years of experience with cast pin restorations. Dent Clin North Am 1970;14:81-91.
9. Christensen GJ. Marginal fit of gold inlay castings. J Prosthet Dent 1966; 16:297-305.
10. Marcum JS. The effect of crown marginal depth upon gingival tissue. J Prosthet Dent 1967;17:479-87.
11. Perel ML. Axial crown contours. J Prosthet Dent 1971;25:642-9.

0022-3913/$30.00

doi:10.1016/j.prosdent.2005.02.018