A novel post-and-core restoration system – results of three years of clinical application of the "Wuerzburg post"

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The Wuerzburg Post is a new post-and-core restoration system designed to eliminate the weak parts of post-and-core restorations and the associated problems, respectively. In contrast to conventional posts, the Wuerzburg Post is a short and thick post, which no longer relies on cementation or luting for retention in the root, but on stress-free positive locking, which it achieves by means of a post which can be spread into a predefined and form-congruent undercut cavity. The second key feature is an annular groove which runs in the dentin, girded by a corresponding structure, ensuring regular force transmission and stress dissipation, as opposed to the classic ferrule design. There are two versions: one with a machined core which can be prepared like a classic build-up to support crowns and bridges, and another one with a 2.25 mm ball end to connect to common dies which can be integrated into removable prostheses. As the system utilizes prefabricated parts made from Titanium, a precise fit is ensured, enabling the user to restore teeth quickly and easily. Over the course of the past three years, 129 posts were inserted, most commonly on upper and lower incisors and canines. The main application was restoration of fractured telescopes. During the observation period, five failures were observed. Two of the failures did not cause significant damage to the tooth, and were subsequently immediately repairable. The survival rate amounts to over 95% after three years under risk.

**Key words:** dental, restoration, post and core, biomechanics
INTRODUCTION

Post-and-core restorations of endodontically treated teeth are still a common way to make prostodontic use of teeth with destroyed clinical crowns but with intact roots, able to support fixed or removable prostheses.

For over a century, restoration materials in use were mainly gold-alloys and mercury amalgam. Without the availability of dentine adhesives, restorations were usually fixed to the teeth using cement and had to be shaped in such a way as to ensure a positive locking of the restoration in the remaining dentine. This was a particular problem when coronally destroyed teeth had to be restored after endodontic treatment. High lateral load components pose a particular risk to such post-and-core restored teeth. These loads occur physiologically for incisors and canines due to the anterior and canine guidance (1, 2) as well as for all teeth supporting removables (3-5).

To overcome this problem, the standard procedure was to insert a long metallic post into a slightly widened root canal and to attach a core build-up recreating a surface which would then provide retention for crowns and bridges. From a mechanical perspective, such a post-and-core restoration must fulfill two basic requirements:

1: The in-vivo loading forces must be transmitted from the post-and-core to the root dentine in such a way that the maximum tensile and compressive forces do not exceed the limits of the dentine. Avoiding localized stress raisers is typically achieved by choosing a large diameter of the post.

2: The joint between the dentine and the dowel material must be dimensioned and shaped to provide for maximum fatigue resistance. This requires a certain minimum interface area usually achieved by a long post.

However, it has been shown for cast metallic posts that stress distribution can be beneficially influenced by choosing a larger but shorter post (6).

With the advent of first enamel- and later dentine-adhesives and a whole new range of post materials (fiber reinforced plastics and ceramics), a paradigm shift occurred: the wide range of mechanical and chemical properties of the new materials at hand enabled to re-focus on the biomechanics of such restorations. However, most existing systems have been optimized but have not evolved beyond the original post-and-core concept. Failure occurs less frequently, but a post-and-core restored tooth supporting a denture still poses a substantially higher risk than a tooth not treated in such manner (7). The trade-off between fracture and fatigue strength of the restoration and the requirement to not weaken the root or shorten the remaining root canal filling too much (8, 9) produced a large variety of systems with different designs using different materials (10). All current designs have their specific weaknesses and strengths and even though some guidelines exist (11), there is no straightforward way to decide which system is the most suitable for a specific patient’s oral situation (12). In a recent
review (13) it was pointed out that there is a lack of randomized clinical studies to allow an evidence based decision of which system to use.

Generally, any kind of leakage due to failure of the adhesive seal of the restoration under load or by shortening of the remaining root canal filling can lead to formation and propagation of oral pathogens (21, 22). First attempts to achieve positive locking did not produce desired results in terms of stress and fatigue resistance (14-16). In order to make full use of the possibilities of both the current dental materials and the available engineering tools, the aim was to optimize the stress distribution and maximize the load carrying capability of the remaining tooth via an improved interface between post and root.

In order to avoid as possible all of the drawbacks of existing post-and-core systems, the “Wuerzburg Post” was designed with the following design parameters:

- use of prefabricated parts in order to avoid impression taking
- no additional step in the dental lab
- short post to reduce apical leakage and risk of perforation
- large post diameter for effective transmission of forces
- post-and-core as one rigid and fracture-resistant unit
- core suitable for fixed and removable prostheses
- stabilization of the cervical dentine analogous to a ferrule effect
- positive locking between the post and the tooth to eliminate reliance on the fatigue strength and retention of the luting/bonding agent.

The resulting design (Principle of the system: Fig. 1, post design: Fig. 2) was optimized for use in incisors, canines and premolars, which are difficult to restore with conventional posts for reasons mentioned above.

The details of the new design together with in-vitro-test results and finite element analyses have been published elsewhere (10, 17).

It is important to note the function of the ferrule and corresponding annular groove (each 0.5mm wide and deep) of the design. With the inversely conical

![Fig. 1. Principle of the Wuerzburg Post: from left to right: pilot bur (formation of center bore and annular groove), undercut bur (extension of apical portion of center bore to inverse conicicity), post placement]
joint, any forces trying to extract the post from the root will give rise to a strong wedge-like effect generating large tensile stress in the dentine surrounding the post.

The groove and corresponding ferrule stabilizes the dentine and reduces the tensile stress.

It works in analogy to the same effect successfully implemented in regular post-and-core restorations (18, 19) but is integrated directly in the core design. The post-and-core is a single piece, pre-fabricated titanium part with the concentrical outer rim that fits into the groove prepared in the root. Two designs are available: either a regular core that can be individualized for fixed prostheses and another one with a ball attachment for removable dentures (Fig. 2).

MATERIAL AND METHODS

The basic idea to achieve positive locking was to prepare an inversely tapered cavity in the tooth. Into this cavity a post is inserted that can be spread to match the shape of the cavity. The clinical application of a Wuerzburg Post requires four steps.

The clinical procedures for preparation and fitting of the Wuerzburg Post only differ in the very last steps, depending on the anticipated restoration.

1. First, preparation of a bore with defined dimensions perpendicular to a planar surface surrounded by a concentrical annular groove is carried out. This is done in one step with a special diamond bur (Fig. 3).

2. Into this bore a matching cylindrical diamond bur is inserted. This bur can be spread at the bottom to an inverse taper by inserting a pin into a center bore of the bur. This pin connects either to a low speed contra-angle hand piece or a handle and acts simultaneously as spreader and drive (Fig. 4).
3. The cavity is now ready to take up the post which can be spread in a similar way. The post is then luted to the dentine using Panavia Light (Kuraray Medical Europe, Frankfurt a.M., Germany) to provide a tight seal (Fig. 5). The cavity is primed with the proprietary agent and filled with the luting composite. The post is covered with a layer of Panavia, too and subsequently inserted while in cylindrical shape. After insertion, the center pin is pushed into the post, spreading the bottom part to match the shape of the cavity. After a 3 minute application of “Oxyguard” (Kuraray) the (dual cure) Panavia F 2.0 is light cured for 20 seconds per surface. After a total set time of 7 minutes, the composite has completely cured, and the excess of the spreader pin can be cut off with a diamond bur and smoothed subsequently.

4. The final step for the ball-ended-version was to seal off any exposed dentine with a flowable composite. The post-and-core version was individually prepared using a diamond bur. Further treatment is identical to conventional ball-ended post systems and core-buildups, respectively (Fig. 7):

After fitting and masking of undercuts of the appropriate die (typically the Dalbo Plus, Cendres & Métaux, Biel, Switzerland was utilized) using a bite impression silicone (Futar D, Kettenbach Dental, Eschenburg, Germany), the die was embedded into the telescope either using a metacrylate (Paladur, Heraeus-Kulzer, Hanau, Germany) or a composite following conditioning of the telescope (ProTemp3 Garant, 3M Espe AG, Seefeld, Germany).

In case of the post version, impressions can be taken with established materials (in cases treated in the study, Impregum, 3M Espe, Seefeld, Germany, was used).

Potential patients were screened according to diameter of the tooth in question and fracture line of the stump, which was to be at least isogingival and not inclined at a too steep angle. After treatment, inspections were conducted either along with the regular recall, but no later than twelve months after insertion with less compliant patients. The participants gave their written informed consent and the study was approved by the local ethics committee.

Fig. 3. In the first step, a cylindrical base hole and an annular groove are machined into the root’s surface with a proprietary diamond bur (top: before insertion, bottom: in-situ).
Fig. 4. Subsequently, the bore is expanded at its apical end to yield an inversely conical cavity (top: lamellae in cylindrical shape, bottom: spreader fully inserted with spread lamellae)

Fig. 5. View of the finished cavity.
Fig. 6. Insertion of the post using a composite for tight seal.

Fig. 7. Ball ended version of the Wuerzburg Post in situ. The spreader pin is inserted and the excess ready to be cut off.
RESULTS

Over the course of the past three years, 129 posts were inserted. *Fig. 8* shows the distribution of restored teeth. As mentioned above, the Wuerzburg Post was primarily intended for anteriors and premolars, so no molars have been restored to date. Lower incisors were not restored mostly due to the fact that their small dimensions did not permit restoration with the novel system.

At this point it is necessary to stress that in this study, teeth which had fractured after a minimum of one foregone restoration or which had suffered severe decay, were treated with the Wuerzburg Post.

For either crowns or bridges the post-and-core-version was inserted 27 times, but the majority of restorations was made using the ball-ended version of the post to restore fractured telescopes (102).

The longest recorded duration of a post in situ is slightly over 3 years (37.4 months) at an average of 12.7 months.

The resulting survival rate amounts to 96.1%, at a survival probability just shy of 90% over the observation period (89.8%, Kaplan-Maier survival rate analysis) (*Fig. 9*).

A total of five failures were observed: two of the failures originated in a fracture of the dentine along the cervical rim of the tooth supporting a ball-ended post after

![Fig. 8. Distribution of restored teeth (maxillary vs. mandibular). No lower incisors where treated due to small root cross sections.](image-url)
a five months in-situ. Fortunately, damage caused to both teeth was minor so that after a second preparation, new Wuerzburg Posts could be re-inserted in both cases.

Two more teeth were lost after 18 and 20 months due to secondary caries following the loss of the composite dentine seal.

The fifth failure was discovered by means of an X-ray immediately after fixture of a post. An air-bubble had been trapped under the spreadable end, causing a defect in the composite lining and therefore impeding stress transmission. The post was removed, and after cleaning and re-conditioning of the cavity, a new post could be affixed.

DISCUSSION

The Wuerzburg Post presents an entirely new method of a mechanically tight joint between post and root which eliminates the necessity of a luting/bonding agent for stress transmission. The study conducted over a period of over three years reflects a very good survival rate of the restoration with virtually no
failures attributed to the positive locking characteristics of the post or other side-effects, much more in the light of a negative preselection of restored teeth.

There are several strong points of the system: at a wide range of indications (to the authors’ knowledge there is no other purpose-built post system which supports removables), it is safe to apply by greatly reducing risk of perforation of the root.

It also has a feature of removability which enables teeth to accommodate multiple posts after e.g. endodontic revision becomes necessary.

By incorporating abutment and post in one prefabricated unit and minimizing the steps required for preparation, significant cost and time savings are achieved: in less than 10 minutes, a core can be added to a decayed tooth, and restoration of teeth supporting removable dentures typically takes around 30 minutes without additional steps in the dental laboratory, which add cost and usually necessitate another visit of the dental office by the patient (20). The costs of the system lie well below individually cast post-and-cores and are comparable with established prefabricated post systems.

It is also important to note that if necessary, it is possible to remove the Wuerzburg Post in a reasonable time without extensive risk of destroying the remaining tooth. This involves destructive separation of the buildup or ball end with a diamond bur which separates the core from the spreadable lamella which remain in the cavity and can be removed individually. In particular, this feature is helpful when endodontic revisions become necessary.

Many initially promising systems failed to pass the test of time and with the high expectations on long term stability of today’s prosthodontics, a minimum of 3 years is needed in order to make an initial assessment of the stability of a new restorative system. In a clinical study conducted with a total of 129 cases and an observation period of over three years, the concept and design of the Wuerzburg Post have proven to work well without any visible drawbacks.

In order to make well founded statements on the long term stability of the system, further data will be collected with more cases and for a longer period of observation.

For a direct in vitro comparison to conventional post-and-core designs cyclic loading under varying temperatures will have to be carried out.

To expand the indications while satisfying the growing demand for highly aesthetic prosthodontics, the use of alternative materials such as circonia are beinginvestigated. Lastly, the stress-transmitting structures such as the annular groove and positive locking joint are subject to possible design evolutions following further testing.

Conflicts of interest statement: None declared.

REFERENCES


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