However, the product of this research will be crucial to Endodontics and to the better understanding of the role of leakage in the outcome of root canal treatment. It will take several years before the endodontic community will be able to interpret and fully comprehend the results of these potential studies.

Optimistically, the role of laboratory leakage studies will be elucidated and a solution to the question whether laboratory leakage studies can anticipate, with reliability, the clinical performance of either a material or a technique? Examples from the literature on adhesive restorative materials are available, where some clear associations were detected when laboratory and *in vivo* bonding effectiveness data were correlated (Van Meerbeek *et al.* 1998, De Munck *et al.* 2005). Adhesives that performed less well in several independent laboratory studies also appeared to be less effective clinically. So, in contrast to some views within the endodontic community, clinical effectiveness of adhesives can be predicted in part by laboratory findings (Van Meerbeek *et al.* 1998, De Munck *et al.* 2005). This may be a consequence of the stronger evidence-based level of the adhesive restorative studies. Nevertheless, if this kind of association could be deduced from endodontic studies, it would represent a considerable evolution in the assessment of the new root filling materials and techniques.

Hopefully, the results of studies evaluating laboratory leakage and clinical outcomes will create a better evidence base to support the use of specific materials and techniques when filling canals for the benefit of patients.

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Response

Dear Editor,

I agree with Dr De-Deus that the findings of Oliver & Abbott (2001) and Susini *et al.* (2006) could be interpreted in a number of ways. Firstly, linear dye penetration only measures the length of the longest void in a root filling; clearly, the results of such measurements do not provide sufficient information to make valid conclusions on the sealing ability of root fillings (Wu & Wesselink 1993, Camps & Pashley 2003). Whether the results of other leakage

models correlate to the outcome of root canal treatment remains to be tested. Secondly, it should not be forgotten that the negative predictive value for periapical radiographs is as low as 55% and for panoramic radiographs, the equivalent figure is 44% (Estrela *et al.* 2008), indicating that 45–56% of radiographic 'successes' are probably associated with disease, that is, apical periodontitis. Radiographical evidence of apical pathosis (success/health failure/disease) is the major reference used to determine the outcome of root canal treatment. If the key reference is so unreliable, how is it possible to detect a link between the (real or histological) treatment outcome and the results of leakage studies? In several universities, the treatment outcome and risk factors are being studied using computed tomography (Estrela *et al.* 2008). Hopefully, in the near future, we will be able to evaluate which, if any, laboratory research model is clinically relevant. It must be stressed, however, that the clinical treatment outcome will be influenced by a number of factors, among which the sealing ability of root filling is but one. Following root canal treatment, bacteria in the form of a biofilm often remain in apical ramifications, regions of the apical canal beyond working length as well as accessory canals, which are not filled (Nair *et al.* 2005). Thus, peri-apical healing may not occur after treatment despite the fact that the main root canal has been well cleaned and sealed because the bacteria remaining in canal ramifications and accessory canals could sustain peri-apical inflammation and the persistence of disease. Therefore, I do not agree that all leakage studies should be rejected simply because the results have not been demonstrated to be related to the radiographic outcome of treatment.

The reliability of various leakage models remains to be evaluated. Bacterial penetration is capable of demonstrating the existence of at least one through and through void. A large number of bacteria penetrating through a filled root canal may indicate a wide through and through void, while a low number may indicate a narrow void (Clark-Holke *et al.* 2003). However, the relevance of early or postponed leakage within a short experimental period (for instance 60 days) is unknown. Furthermore, the antimicrobial effects of all tested filling materials should be considered within the context of microbial leakage studies (Editorial Journal of Endodontics 2007).

In the glucose penetration test, glucose solution flows along a filled root canal under a head space pressure of approximately 14 cm H_2O (Xu *et al.* 2005). It is important to remember that some materials may react chemically with glucose. In a study by Shemesh *et al.* (2008), discs of various materials were immersed in glucose solution for 1 week and it was found that Portland cement, MTA, calcium sulphate, calcium hydroxide and sealer 26 reduced the concentration of glucose significantly through absorption, a factor that will distort the results of such leakage tests.

I agree with Dr De-Deus that the sealing ability of root fillings is important and that this parameter should continue to be used as a factor to rank and evaluate new materials. However, it is essential that publications of inferior quality should be rejected. Although it is essential there are no flaws in design and methodology, it is also important to check whether submitted papers present originality of thought. Publications that add little to our knowledge, though having no flaws in the design or methodology, should be rejected. Confounding factors should be standardized as much as possible. For example, canals in single-rooted teeth differ significantly in diameter and shape, thus, it must be ensured that experimental groups of teeth are comparable anatomically. Furthermore, root canals should be cleaned well; effective control groups should be present and comparison with all other relevant studies in discussion sections, rather than selected supportive literature only, should be mandatory. When results are at variance, a convincing explanation should be provided and all possible interpretations should be considered. In short, leakage studies should be critically assessed as would all other studies submitted for publication in peer review journals.

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