Meredith Smith and Johanson (1) suggested that “real” teeth evolved at least twice, based on their purported absence in basal placoderms and their presence in more derived placoderm taxa and all other more crownward-jawed vertebrates. The assertion by Meredith Smith and Johanson that the dental structures in the derived placoderms are “real” teeth is based on two criteria: That the “tooth” development was patterned and regulated (from which a dental lamina was inferred), and that the “teeth” are formed of regular tubular dentine. I believe that this conclusion is based on a false premise, as tubercles forming staggered rows—similar to those illustrated in (1)—are seen on the gnathals (jaw bones or plates) of several basal placoderms. The arrangement and morphological and histological structure of these tubercles is often comparable to that of the tubercular ornament on dermal plates forming the head and trunk shields.

Pivotal to the proposal in (1) is the assumption that the dentition in basal placoderm groups comprises “denticles in various arrangements” rather than true teeth. This is true in the sense that these structures are not “true teeth.” “Dental” plates and gnathals with denticles or tubercles that acted as teeth have been described in at least two of the putative basal clades of their placoderm phylogeny: Bothriolepis (2, 3) in the Antiarchi, and Gemuendina (4) and Jagorina (5) in the Rhenanida. Isolated “tooth” plates have also been tentatively assigned to acanthothoracid placoderms (6). In most of these instances, the denticles are not randomly distributed, but form regular rows, increasing in height along the row (Fig. 1, A and B). Certainly within the Arthrodira, “dental” or gnathal plates with ordered denticles are widely distributed, marked by their presence in phylactodonts (7) and actinolepids (1), as well as primitive and advanced brachythoracids (8).

Unfortunately, the rarity of Early Devonian articulated placoderms with gnathals has generally precluded sacrificing such dental elements to thin sectioning. Despite this lack of histological information, many researchers have supported the view (based on morphology) that a process equivalent to normal tooth replacement occurred in several placoderm groups (9). These toothlike structures have not classically been interpreted as “real” teeth. However, their structures show a regular arrangement consistent with their addition being “regulated in time and space with others of the set”—a feature that Meredith Smith and Johanson asserted was lacking. A similar arrangement of denticles or tubercles is also seen along the margins of many placoderm plates (Fig. 1C). Irrespective of this regularity, the histological structure of marginal jaw dentition in those Early Devonian taxa previously investigated is comparable to that of tubercles elsewhere on the dermal skeleton (Fig. 1, A, B, D, and E).

The other main criterion for interpreting the dental structures of eubrachythoracid placoderms as real teeth in (1) was their “regular tubular dentine” composition. Several vertebrate groups, including Osteostraci, Acanthodii, Actinopterygii, and Placodermi, show a phylogenetic change within lineages from cellular dentine to acellular dentine in the tissue forming their dermal bone and scale ornament (10). Thus, many basal placoderm taxa have cellular dentinous tissue (mesodentine or semidentine), and some more derived taxa lack dentine, or have acellular dentine (orthodentine or similar). More specifically, placoderms from several groups have scale tubercles with an outer zone of tissue formed of regular subparallel dentine tubules which, in some taxa, run into vascular canals (11). These tubules are similar to those in the “teeth” of advanced brachythoracids, as illustrated in (1), and the tissue should therefore not necessarily be interpreted as arising de novo. It is clearly not restricted to toothlike structures on the jaws, because similar tissue occurs in the marginal denticles on some placoderm spinal plates (Fig. 1F). In conclusion, the evidence still over-

Fig. 1. Early Devonian placoderm dermal and dental plates. (A) Gnathal plate, GSC123600, probably from an acanthothoracid placoderm (Lochkovian); Prince of Wales Island, arctic Canada. (B) Vertical section of the plate in (A), at the level of the asterisk; poorly preserved but showing growth lines marking successive addition of larger tubercles and basal plate (to left). (C) Rows of tubercles of increasing size on the edge of an acanthothoracid plate, MMMC02255, from the Connemarra Formation (?late Lochkovian/early Pragian); central New South Wales. (D) Medial view of arthrodir right infragnathal, MMMC02637, from the Troffs Formation (?early Emsian) showing staggered rows of smooth tubercles; central New South Wales. (E) Vertical section of the infragnathal in (D), medial side to right, at the level of the asterisk; heavily fractured and poorly preserved but showing little structural differentiation from base to tubercle apex. (F) Vertical section of a denticle on a placoderm spinal plate, MMMC02638, from the Gleninga Formation (late Pragian or early Emsian), showing subparallel dentine tubules leading into vascular, or “pulp,” canal; central New South Wales.
whelmingly supports the derivation of placoderm “teeth” from denticles of the dermal skeleton, and fails to support the interpretation of these structures as “real” teeth.

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