changes in 39.0% and 6.2% of patients, respectively, while other studies investigating orthodontic populations report degenerative TMJ changes in only 0.5% to 3.6% of subjects [19,20]. It has been demonstrated that the progression and severity of TMJ osseous changes are increased with advancing age [70,71]. This lower incidence of degenerative changes in our sample, and other orthodontic cohorts in the literature, is likely due to the nature of an orthodontic population, i.e., consisting primarily of adolescents.

Cervical vertebrae region

Cervical vertebral findings represented only 1.3% of all CBCT findings, a similar prevalence to other CBCT studies examining orthodontic populations [17,20]. This low rate of vertebral findings may be expected, given the low mean age of our orthodontic sample and variation in the number of vertebrae included in each of the scans. This is in contrast to CBCT studies by Pette et al. [14] and Allareddy et al. [21] which examined samples with much higher mean ages. In these studies, cervical vertebral findings were respectively identified in 47.8% and 9.7% of subjects, with the degenerative changes representing the main finding. Vertebral fusion was the most predominant finding in this region in our sample (0.6%). The prevalence as demonstrated in other studies is 0.4% to 0.7% with no sex predilection, with C2-C3 being the most common location [72]. Generally, patients are asymptomatic, but increasing age or injury may precipitate symptoms as discal tear, rupture of the transverse ligament, and odontoid process fracture are common consequences. In addition to vertebral fusion, other findings have been identified in CBCT studies, including osteoarthritis, clefts, subchondral cysts, and osteophyte formation [14,20,21]. Many abnormalities of the cervical spine do not manifest themselves symptomatically until young adulthood, and if progressive degenerative defects are identified early, this may aid in the mitigation of the severity of their consequences [73]. With CBCT, the orthodontist and/or OMFR may be the first person to detect them and thus serve to screen and to refer for further assessment.

In our orthodontic sample, of the 842 reported findings, 718 (85.3%) were located in extragnathic locations (i.e., outside the dentition and alveolus). This is comparable to similar CBCT studies in the literature. Price et al. [18], in a sample of 300 consecutive patients, reported a total of 881 incidental findings, with 775 (88.0%) of these being extragnathic. In a sample of 318 dental implant patients, Pette et al. [14] reported that 93.7% of subjects had incidental extragnathic findings. They also identified both vascular and intracranial findings that were not reported in our sample. Internal carotid artery (ICA) calcifications were reported in 23.6% of their subjects and pineal gland calcification in 19.2% [14]. ICA calcifications were also identified in 5.7% of CBCT subjects by Allareddy et al. [21]. Similarly, ICA calcifications in CBCT were identified in 4.8% of subjects by Price et al. [18]. These findings were likely not identified in our sample due to major differences in mean age, as advanced age has been demonstrated to be a major risk factor for ICA calcification [74]. In panoramic imaging of large samples, Bayram et al. [75] and Kumagai et al. [76] respectively reported that ICA calcifications were identified in 2.1% and 4.0% of subjects. However, the presence of ICA calcifications does not always imply stenosis. The gold standard for the diagnosis of carotid artery stenosis (CAS) is duplex ultrasound and is utilized in cases of suspected CAS [77]. A number of studies have compared the incidence of ICA calcifications identified on panoramic radiography to CAS [77-80]. These studies, investigating populations over the age of 55, have observed positive ICA calcification in 2% to 5% of images [78-81]. Therefore, panoramic radiographs appear to be a valuable screening tool for CAS. However, due to the advantages of CBCT imaging (i.e., lack of overlapping structures, submillimeter voxel resolution, etc.), it may result in superior and more accurate screening for CAS. The relationship between ICA calcifications identified in CBCT imaging and CSA identified in duplex ultrasound must be further evaluated.

The frequency of IFs in CBCT imaging is much larger in number and in scope when compared to traditional 2-D imaging. Bondemark et al. [51] and Asaumi et al. [82] reported that incidental findings were respectively identified in only 8.7% and 6.1% of patients when panoramic radiographs were reviewed. Granlund et al. [66] reported an IF frequency of 2.2 IFs per panoramic image, a rate that is consistent with CBCT studies. However, in these three studies, there is no mention of airway, vascular, or cervical vertebral findings, presumably because these anatomic structures are poorly visible in panoramic imaging. Consequently, between 75.0% and 100% of the reported findings were confined within the dento-alveolus [51,66,82], a region that dental clinicians should be competent in interpreting. This is in sharp contrast to CBCT studies.

Table 4 Number of incidental findings reasoned to require follow-up

Anatomic location	Incidental findings, *n* (%)	Findings requiring follow-up, *n* (%)
Cervical vertebrae	11 (1.3)	1 (0.1)
Dentoalveolar	124 (14.7)	19 (2.3)
Naso-oropharyngeal airway	356 (42.3)	23 (2.7)
Paranasal sinuses	260 (30.9)	22 (2.6)
Surrounding soft/hard tissues	34 (4.0)	11 (1.3)
Temporomandibular joint	54 (6.4)	18 (2.1)
Total	842 (100)	94 (11.2)